Special Operations Forces (SOF) Support Ship
Ship Conversion Feasibility Study

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Executive Summary

This report describes the results of a high-level concept exploration conducted for the 21st Century Special Operations Forces Ship. The study began with a detailed examination of the Sponsor Requirements and development of a Mission Need Statement. An initial design sequence was performed with the goal of maximizing Overall Measure of Effectiveness (OMOE) for minimum cost. The OMOE and cost of the ship were determined by applying modified versions of the Massachusetts Institute of Technology (MIT) OMOE and Cost Models. After analyzing several possible variants using OMOE versus cost optimization techniques, a single design was selected for further evaluation and refinement.

One of the driving factors was to be able to produce this and any follow-on ships at relatively low cost. In order to do this, mature technologies were used, particularly in the area of communications, berthing accommodations, and previous designs and arrangements were emulated to exploit repeatability and to reduce cost. The Large, Medium-Speed, Roll-On/Roll-Off Ship (LMSR) was used as the starting point for the variant characteristics in an effort to leverage on previous design efforts.

The Program of Ships Salvage and Engineering (POSSE) software package was used to analyze a modified midship structural section and to perform intact and damaged stability analyses. Finally, seakeeping of the design was analyzed using the Ship Wave Analysis (SWAN) program. The ship design has undergone numerous changes since the study's inception. The current design is extremely stable and meets all of the project engineering constraints. The final baseline design meets current naval performance standards. According to a weight-based cost model, the lead ship conversion cost estimate is $86.16 million. This is within the threshold value of $90 million. The baseline design characteristics are provided below:

SOF Ship Dimensions and Performance

LBP	884 ft	**LOA**	951 ft
Beam	106 ft	**Full Load Draft**	27.80 ft
Full Load Displacement	48,937 ltons	**Light Ship Displacement**	37,681 ltons
Full Load KG	39.98 ft	**Light Ship KG**	45.57 ft
Max speed	24.0 knots	**Endurance**	10,000+ nm @ 24 knots

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1.0 MISSION NEED

1.1 Defense or National Guidance and Policy

The Mission Needs Statement (MNS) provides requirements for a Special Operations Forces (SOF) platform. The MNS is included in Appendix A.

The need for such a ship is addressed in part by the Joint Chiefs of Staff:

> "The landmark Strategic Mobility Requirements Study by the Joint Chiefs of Staff in 1992 concluded that the United States had insufficient sealift capacity to transport military equipment to an overseas conflict. This shortfall was highlighted during Operations Desert Shield and Desert Storm when the majority of cargo had to be moved by chartered, non-U.S.-flag ships. To address this capacity shortfall, Congress authorized the Strategic Sealift Program."[1]

Although this program provides afloat prepositioning of Army equipment, the need for immediate transport of SOF can be directly related. This is evident in the war on terror in Afghanistan where USS Kitty Hawk (CV-63) was taken from her assigned duties to serve as a SOF transport and support platform. The MNS should be used to guide SOF platform design, research, development, and cooperative efforts with U.S. Allies. Based on the MNS guidance and policy, the SOF platform must provide support for interagency, joint, and allied forces. This vessel will provide modular flexibility to perform individual or multiple missions, thereby freeing other major assets to dedicate their full resources to the performance of their primary missions.

1.2 Threat Analysis

The SOF platform itself can be characterized as a non-combatant; however, the mission of the forces it transports is offensive. The SOF platform serves as a mobile offshore base from which SOF can be deployed.

1.3 Current Capability Assessment

Currently there is no platform specifically designated for SOF purposes. Submarines, aircraft carriers, and other surface ships are detailed as needed for SOF deployment. A recent example, as mentioned previously, is USS Kitty Hawk (CV-63) which was relieved of carrier duties to provide SOF support for Operation Enduring Freedom (i.e., the war on terror in Afghanistan).

1.4 Capability Need

The logistics and costs associated with utilizing an operational and fully manned aircraft carrier for SOF missions is expensive. A need exists for a platform specifically tasked with the transport, support, and deployment of SOF that can operate jointly with other naval forces. This platform would allow for rapid deployment of SOF, as well as SOF aviation and SOF boat support. Timeliness, versatility, and flexibility are essential to global power projection.

1.5 Recommended Alternatives

Non-material alternatives, such as changes in doctrine or operational concepts, are not sufficient. Part-time tasking of vessels like USS Kitty Hawk removes an essential element of the fleet and employs her in a role for which she was not specifically designed. Material alternatives include (1) conversion of an amphibious assault ship, (2) conversion of a commercial tanker/container ship/roll-on roll-off vessel, (3) conversion of an existing LMSR ship, and (4) design and acquisition of a new ship.

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[1] Strategic Mobility Requirements Study, 1992

2.0 DESIGN REQUIREMENTS AND PLAN

2.1 Required Operational Capability

The Required Operational Capabilities (ROC) are based on guidance given by the sponsors of this ship conversion. Table 1 lists the sponsor requirements (SR), while Table 2 lists the ROCs for the SOF ship. Measures of effectiveness (MOE) assess the degree to which the various design concepts meet these ROCs. The MOE are listed in Table 3.

Table 1. Sponsor Requirements (SR)

SR #	Sponsor Requirement
SR1	Provide platform for SOF/Aviation support missions
SR2	Total acquisition and conversion cost not to exceed $90 million
SR3	Low operational costs
SR4	Reduce operational tempo of assets currently supporting SOF missions
SR5	Provide test platform for future SOF technology
SR6	Provide weight/space margin for insertion of future modular SOF systems
SR7	Maintain partial Roll On/Roll Off capability for prepositioned disaster relief

Table 2. Required Operational Capabilities (ROC)

ROC	Area of Operations
1	Steam to design capability in most fuel efficient manner
2	Conduct SOF deployment and support operations
3	Provide own unit's C4I functions
4	Provide platform for launch and recovery of multiple rotary-wing and VTOL/STOVL aircraft for SOF aviation missions
5	Provide minor maintenance to aircraft
6	Provide refueling to aircraft
7	Provide platform for Navy Special Boat Unit operations
8	Provide search and rescue capability
9	Provide ability to install/test new technology
10	Provide accommodations and medical facilities for SOF personnel
11	Prevent and control damage
12	Perform seamanship, airmanship and navigation tasks (navigate, anchor, mooring, scuttle, life boat/raft capacity, tow/be-towed)
13	Replenish at sea
14	Maintain health and well-being of crew
15	Provide upkeep and maintenance of own unit

Table 3. Measures of Effectiveness (MOE)

MOE #	Associated MOE
1	Support SOF operations
2	Support SOF aviation missions
3	Support Navy Special Boat Unit missions
4	Support aircraft maintenance/refueling
5	Support partial Roll On/Roll Off disaster relief operations

2.2 Concept of Operations/Operational Scenarios

The SOF Ship Concept of Operations (COO) is based on the expected SOF mission needs and operating characteristics. The notional composite scenario is outlined in Table 4. Due to classification requirements, the operational missions of SOF can not be included in this report.

Table 4. Notional Composite Scenario

Day 1-10	Transit to Operational Area 1
Day 11-18	Support SOF mission and deployment
Day 19-28	Transit to Operational Area 2
Day 29-50	Support SOF mission and deployment
Day 51-60	Underway Replenishment/Return to Operational Area 1(2)

2.3 Constraints and Standards

The MNS identified several constraints on the SOF ship development.

2.3.1 Constraints

2.3.1.1 Design

The ship design must employ a total-ship engineering approach. This approach would optimize Life Cycle Cost (LCC) and performance, permit rapid upgrade in response to evolving operational requirements, and provide the capability to continually perform its mission. The developmental phase must account for emerging technologies, including modern, flexible information processing systems. Since communication and data systems hold the greatest potential for growth, these installations must be as modular as possible to allow for future upgrades. Standard man-to-machine interfaces between onboard systems should be consistent with current Navy practice and systems.

The SOF ship will be modified from its original configuration such that the ramps and large cranes will be removed. The topside configuration will be obstruction-free flight deck

areas both forward and aft of the superstructure. Below decks, the ships holds will be converted to offices, briefing rooms, berthing areas, and other various spaces required to support a SOF deployment. These modifications will be done at a minimum cost without neglecting the comfort of the personnel.

2.3.1.2 Manning

The manning requirements of the SOF ship will be the normal manning of the T-AKR 300. This consists of 30 Military Sealift Command (MSC) civilian personnel, a fraction of what is typically required for an operational naval vessel of this size. Since this vessel will not have any offensive capability and is not envisaged to engage in ship-to-ship warfare, the crew will not be sized for combat condition damage control.

The ship must provide berthing accommodations for significant numbers of personnel for SOF operation. Embarked SOF personnel will be considered in the same manner as an Air Wing embarked on an aircraft carrier, and their accommodations will be maintained separate from the ships crew.

The Navy-wide initiatives in manning reduction will be incorporated into the design of the SOF ship modifications. Recent advances made in habitability, upkeep, and shipboard training should all be investigated for utilization in the below-decks modifications to the LMSR. The forward thinking already used in the LPD-17, CVN(X), and DD(X) projects should be leveraged to provide the best possible use of manpower on the SOF ship.

2.3.2 Standards

The following standards were used in the development of this conversion design:

- General Specifications for Ships of the United States Navy, NAVSEA S(AA0-AA-SPN-010/Gen-Spec)
- Structural Strength: DDS 100-1,2,4,5,6,7
- Stability and Buoyancy: DDS 079-1
- Freeboard: DDS 079-2
- Ship System Survivability: DDS 072-4
- Powering: DDS 200-1, 310-1.

2.4 Goals and Thresholds

Nominal ship operational capabilities as required by the sponsor are summarized in Table 5.

Table 5. Nominal Ship Operating Characteristics

Maximum Speed	20+ knots
Endurance Speed	14 knots
Endurance Range	10000+ nm
Endurance Stores	60 days
Seakeeping	Sea State 5

The ability of the SOF ship to conduct its mission is paramount. The flight deck should be able to accommodate all U.S. Armed Forces rotary-wing and VTOL/STOVL aircraft that are used in SOF missions. The SOF ship must be able to refuel any aircraft onboard and provide for any repairs that are capable of being done on the flight deck. In addition, while at anchor, the ship must be able to launch, recover, and fuel large SOF tactical boats from the hangar deck.

The SOF ship must be capable of serving as a test bed for new technology. Due to the nature of SOF, much of the equipment may be non-standard or true cutting edge. The ship must be designed with an "open architecture" in mind that will allow for the installation of special equipment.

The ship used for this study, T-AKR 300, has a propulsion plant capable of achieving a speed of 24.0 knots. This speed enables the ship to operate well within joint naval tactical parameters.

2.5 Design Philosophy and Decision Matrix

The goal of this conversion design was to determine the most suitable platform for a SOF ship while minimizing LCC. In fact, throughout this design, cost effectiveness has been of equal or greater influence than mission effectiveness. Generally, the required equipment modifications were performed in order to minimize effects to the existing ship. Each modification carried a cost apart from its mission impact. Each modification, such as removing a system, installing another system, modifying a structure, and so forth, received a cost and weight assessment. The weight reductions or additions for discrete systems came from a weight and balance report for the T-AKR 300 and weight information from CSC Advanced Marine Center. Modification weights were estimated.

The primary mission of this ship is to support SOF missions. Therefore, all other considerations are subordinate to performing this mission. The essential measures of effectiveness reflect fulfillment of the SOF mission, as well as operational requirements for the ship. To assess operational effectiveness, an OMOE model provided a score based on performance relative to the sponsor requirements. This model consists of a weighted-sum of individual MOE scores. The weightings are the averaged results of independent comparisons of all MOE by each design team member. Table 6 lists the OMOE weights.

Table 6. OMOE Weights

Overall		1	
LCC Reduction	Reduced Operational Costs	0.5	0.25
	Reduced Conversion Costs		0.25
SOF Mission	Support SOF Aviation Missions	0.5	0.2
	Support Navy Special Boat Unit Missions		0.2
	Support New Modular Technology		0.1

3.0 CONCEPT EXPLORATION

3.1 Baseline Concept Design

The starting point for the conversion is the T-AKR 300 Bob Hope class ship, which is a Large, Medium-Speed, Roll-On/Roll-Off Ship (LMSR). LMSRs provide afloat prepositioning of Army heavy vehicles and supplies. They are operated by the Military Sealift Command (MSC). The LMSR program currently has 19 ships. These consist of 5 ex-commerical vessels and 14 new construction LMSRs. Table 7 lists the dimensions and performance of this ship. Figure 1 shows the external arrangement.

Table 7. LMSR Dimensions and Performance

LBP	884 ft	LOA	951 ft
Beam	106 ft	Full Load Draft	37 ft
Full Load Displacement	62,069 Ltons	Light Ship Displacement	33,026 Ltons
Full Load KG	45.29 ft	Light Ship KG	47.47 ft
Max speed	24 knots	Endurance	12,000 nm @ 24 knots

The T-AKR 300 ships have a cargo capacity of 13,250 long tons with 397,413 square feet of available cargo area. They provide roll on/roll off (RO-RO) capability, and lift on/lift off capability. The ships are powered by four Colt Pielstick 10 PC4V diesel engines that can produce a speed of 24 knots at a design draft of 35 feet. The Bob Hope class is currently being built for the US Navy by Avondale Industries. The oldest ship was commissioned in 1998, so a long service life is expected. This 951 foot long LMSR is an excellent platform on which to perform SOF ship modifications.

Courtesy of www.globalsecurity.org

Figure 1. LMSR Outboard Profile

The major modifications done to the base hull were the removal of all appendages, ladders, ramps, and cranes above the main deck (designated Deck A). A new deck, or "flight deck," was then attached to the main deck forward of the existing superstructure. The major components added were the systems and support equipment required for self-defense and for SOF operations. These major additions were: (1) two Rolling Airframe Missile Launchers (RAMs); (2) two Close-In Weapon Systems (CIWS); (3) modular C4I system infrastructure; (4) two aircraft elevators; (5) aviation refueling and medium-level maintenance support; (6) two hangar bay boat cranes; (7) increased berthing and messing facilities; and (8) medical and dental facilities.

3.2 Alternative Technologies and Systems

Several technological alternatives were analyzed for this conversion. New technology exists, or is in development, for the modular communication equipment. Similarly, innovations to crew habitability are always being investigated.

The LMSRs are not armed and do not possess a combat system. They do have a C3I suite sufficient to perform standard operations with other naval vessels. As a result, modular C4I systems will be installed. This will reduce not only size and weight from the SOF ship, but also required maintenance and repair costs as well as manning.

Because embarked SOF personnel will be considered in the same manner as an Air Wing embarked on an aircraft carrier, berthing and messing facilities will be maintained separate from the ships crew. Based on the mission requirements of the ship, the berthing on the ship will consist of large, modular berthing compartments, with the exception of berthing for officers who will have larger multi-person staterooms. The food preparation will become more automated and streamlined, using an outside service to support preparation and cleanup of meals, as well as using the new "prepared meals" currently being tested.

3.3 Concept Ship Variants and Trade-Off Studies

An initial search for a ship conversion candidate was conducted based on the criteria given in Table 1 and a combined acquisition and conversion budget of $90 million. Table 8 summarizes the suitable hulls found based on a search using this criteria. The assumption was made that at least one ship from each class was available. To assess operational effectiveness, an OMOE model provided a score based on performance relative to sponsor

requirements. This model consists of a weighted-sum of individual OMOE scores. In each of the five categories below: aviation, boat capability, transformational (support of modular new technology), operational costs and conversion costs, a maximum OMOE was assigned based on the relative importance to the overall mission. The individual items in each category were assigned values between zero and the maximum OMOE assigned to each category as discussed previously in Table 6. As with all ship acquisition and conversions, budget is a concern and was the driving factor for this entire design. Therefore, some hull forms were eliminated on cost consideration alone.

Table 8. Concept Ship Variant Summary

	LPH	LPD	CV	AO	LMSR	Merchant (commercial)
SOF Mission						
Aviation						
Flight Deck	0.05	0.04	0.07	0.03	0.03	0.03
VTOL/STOVL	0.04	0.04	0.05	0.01	0.01	0.01
sum	0.09	0.08	0.12	0.04	0.04	0.04
ratio to max of .2	**0.16**	**0.13**	**0.20**	**0.07**	**0.07**	**0.07**
Boat Capability	0.07	0.07	0.07	0.07	0.07	0.07
ratio to max of .2	**0.20**	**0.20**	**0.20**	**0.20**	**0.20**	**0.20**
Transformational	0.01	0.01	0.03	0.02	0.03	0.03
ratio to max of .1	**0.02**	**0.04**	**0.10**	**0.06**	**0.10**	**0.08**
Costs						
Operational Cost						
Age	0.00	0.05	0.00	0.03	0.08	0.08
Propulsion	0.00	0.05	0.00	0.05	0.08	0.07
Speed	0.07	0.05	0.07	0.05	0.07	0.07
Crew size	0.02	0.05	0.00	0.07	0.08	0.08
Draft	0.05	0.05	0.02	0.05	0.03	0.03
sum	0.13	0.25	0.08	0.25	0.35	0.33
ratio to max of .25	**0.10**	**0.18**	**0.06**	**0.18**	**0.25**	**0.24**
Conversion Cost						
Structure	0.00	0.02	0.07	0.03	0.07	0.03
Tankage	0.02	0.02	0.02	0.07	0.07	0.05
Habitability	0.07	0.07	0.07	0.03	0.02	0.02
C4I	0.05	0.05	0.05	0.03	0.02	0.02
Self-defense	0.07	0.07	0.05	0.03	0.02	0.02
Propulsion	0.02	0.02	0.00	0.03	0.08	0.00
sum	0.22	0.23	0.25	0.23	0.27	0.13
ratio to max of .25	**0.20**	**0.22**	**0.23**	**0.22**	**0.25**	**0.13**

Figure 2 shows that the LMSR received the highest OMOE of the six ship classes considered.   Although one ship might have an advantage for a given category, the LMSR had the highest overall OMOE. As mentioned previously, the LMSR program currently has 19 ships. The oldest ship was commissioned in 1998, so a long service life is expected and availability of the LMSR is not a concern.

Total OMOE for Ships Considered
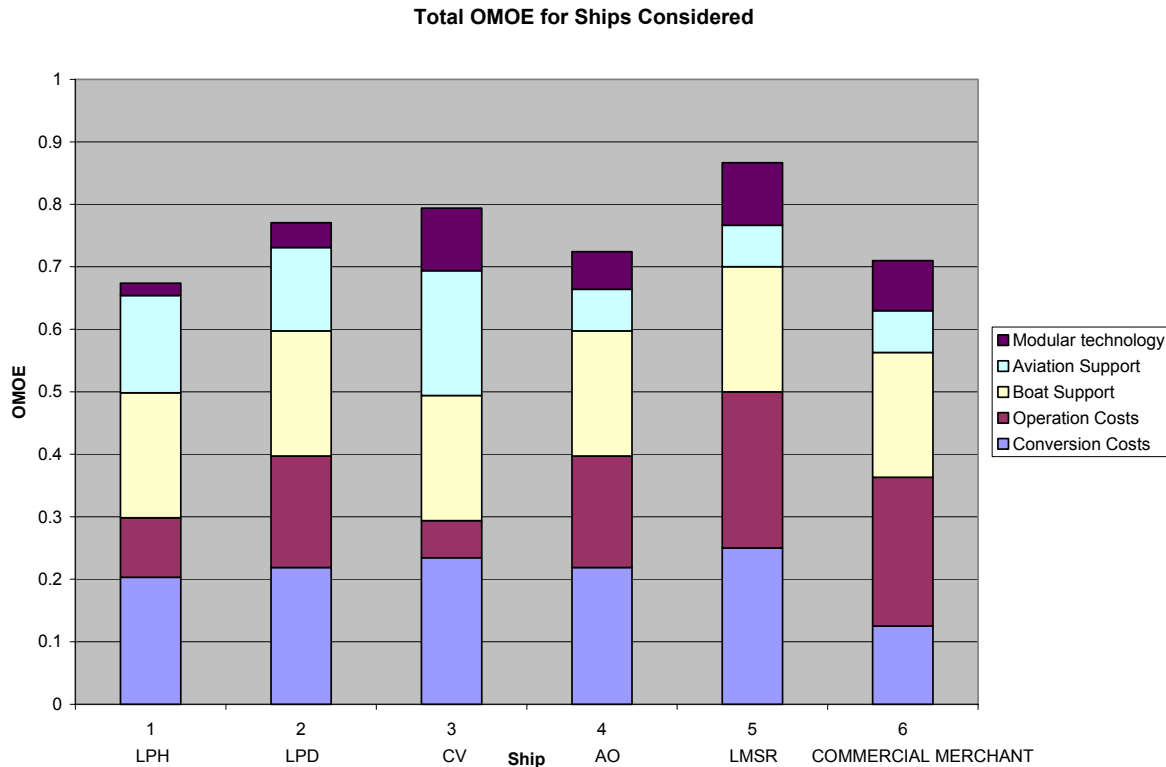
Figure 2. Total OMOE for Ships Considered

3.4 Variant Assessment

The variants defined above in Table 8 and shown in Figure 2 were assigned a scale factor to estimate overall OMOE and costs for each variant. Using cost as the leading driver, only those cost increases that had the potential to improve the OMOE significantly were considered. The OMOE weights are shown again in Table 9. Based on this study, the only variants that are feasible are those that offer new missions, but no ship modifications. Therefore, the design of the ship will be that proposed by the LMSR variant.

Table 9. OMOE Weights

Overall		1	
LCC Reduction	Reduced Operational Costs	0.5	0.25
	Reduced Conversion Costs		0.25
SOF Mission	Support SOF Aviation Missions	0.5	0.2
	Support Navy Special Boat Unit Missions		0.2
	Support New Modular Technology		0.1

3.5 Final Baseline Concept Design

The LMSR is the optimal variant. This became the SOF ship concept design. This design removes all structures above the main deck, and replaces them with a new flight deck forward of the existing superstructure. Although the light ship displacement increased by 4,655 long tons, there was little effect on stability. Since the engineering plant and hull did not change, while the displacement increased only slightly, the speed and endurance remained relatively unchanged compared to the baseline. The other variants are good options, but all lost out due to cost. With cost as the ultimate driver, the LMSR model was the best available choice.

The SOF ship dimensions and performance, after the conversion modifications, are shown in Table 10.

Table 10. SOF Ship Dimensions and Performance

LBP	884 ft	LOA	951 ft
Beam	106 ft	**Full Load Draft**	27.80 ft
Full Load Displacement	48,937 ltons	**Light Ship Displacement**	37,681 ltons
Full Load KG	39.98 ft	**Light Ship KG**	45.67 ft
Max speed	24.0 knots	**Endurance**	10,000+ nm @ 24 knots

Table 11 summarizes the total weight removed from and added to the ship by Ships Work Breakdown Structure (SWBS). The complete list of equipment removed is included in Appendix B. The complete list of equipment added, including SOF support systems and ship self-defense armament, is included in Appendix B.

Table 11. Weights Removed and Added by SWBS

SWBS Group		Weight Removed (ltons)	Weight Added (ltons)
100	Hull Structure	607.37	4389.98
200	Propulsion Plant	15.74	15.74
300	Electric Plant	34.19	69.9
400	Command and Surveillance	0	76.19
500	Auxiliary Systems	695.63	1425.72
600	Outfit and Furnishings	99.09	1405.95
700	Armament	0	38.06
Total		**1452.02**	**7421.54**

4.0 FEASIBILITY STUDY AND ASSESSMENT

4.1 Design Definition

4.1.1 Ship Geometry

The modification from the LMSR to the SOF ship design does not affect the hull form dimensions. Table 12 lists the ship's principal dimensions. Figure 3 shows the outboard profile, both before and after the modifications. The most important changes included the removal of elements above the weather deck (Deck A) including the cranes and ramps. The addition of elements included ship self-defense equipment, SOF crew berthing and messing spaces, C4I System Infrastructure, and Aircraft Elevators. The LMSR Weight and Moment report served as an initial estimate for full load condition, and elements were removed and added in the same format as the LMSR Weight report. A complete list of the elements removed and added is included in Appendix B. A comparison between the main characteristics of both ships is shown in Table 12.

Table 12. LMSR & SOF Ship Principal Dimensions

	LMSR	SOF Ship
LBP	884 ft	884 ft
Beam	106 ft	106 ft
LOA	951 ft	951 ft
Full Load Displacement	62,069 ltons	48,937 ltons
Full Load KG	45.29 ft	39.98 ft
Full Load Draft	37 ft	27.82 ft
Light Ship Displacement	33,026 ltons	37,681 ltons
Light Ship KG	47.47 ft	45.67 ft
Light Ship Draft	20.74 ft	22.63 ft
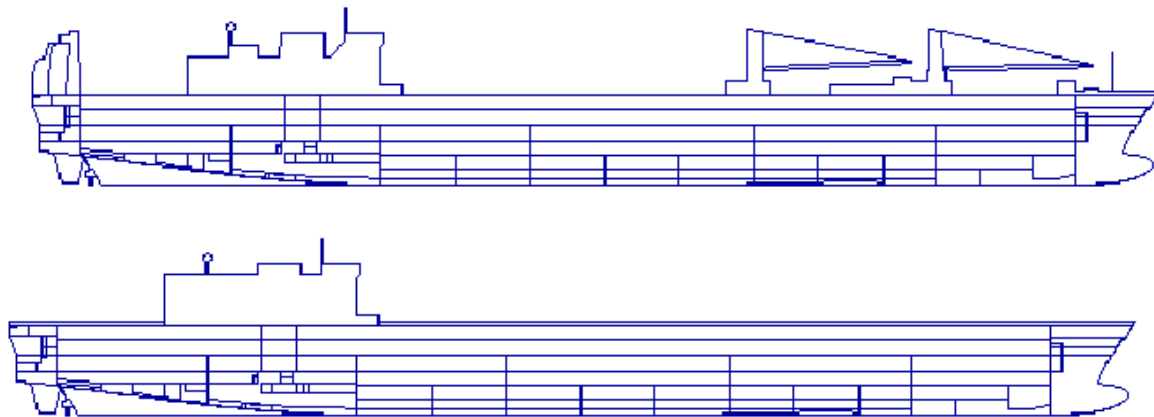
Figure 3. LMSR and SOF Ship Comparison of Outboard Profiles

4.1.2 Combat Systems and Mission Payload

The baseline ship includes Link 11 and Link 14. This offers support for communication between the SOF ship and other Navy ships. Joint support, however, for the SOF ship will require upgrade to Link 16. Central command and control suites will be installed on the 02 and 03 levels just aft of licensed and unlicensed crew staterooms, between frames 99 and 104. As a result, the emergency diesel generator was moved forward to Hold 1 between frames 20 and 33. Self-defense mission modules and the two Rolling Airframe Missiles (RAMs) will also be monitored from the centralized command and control.

Primary flight control will be located on the 04 level. Prior to conversion, the 04 level on the LMSR was empty and only used for access to the pilothouse between frames 85 and 90. Modifications were made to this level to lengthen the entire compartment, imitating the 03 level from frames 85 to 104, to serve as flight control. This allowed for viewing the entire deck during all helicopter operations.

The ship combat systems will be upgraded with the addition of the Ship Self-Defense System (SSDS). The SSDS is comprised of the RIM-116 RAM, the Close-In Weapon System (CWIS), and the decoy launch system. The SSDS integrates the AN/SPS-49, the AN/SPS-67 surface search radar, the AN/SLQ-32 sensor, and the CIWS search radar into a cohesive ship defense system. The SSDS provides a high level of protection against anti-ship missiles and aircraft. The CIWS has a combined coverage of $360°$, while the RAMs

each have 360˚ of coverage. The topside arrangement is shown in Figure 4 and the arcs of fire coverage are shown in Figure 5.

The SOF ship will also have a Global Command and Control System: Maritime (GCCS-M) and Joint Maritime Communication and Information System (JMCIS). All systems must be compliant with the Defense Information Infrastructure (DII) and Common Operating Environment (COE). Furthermore, an additional Command and Control Center is located aft on the C Deck directly under the superstructure for ease of access.
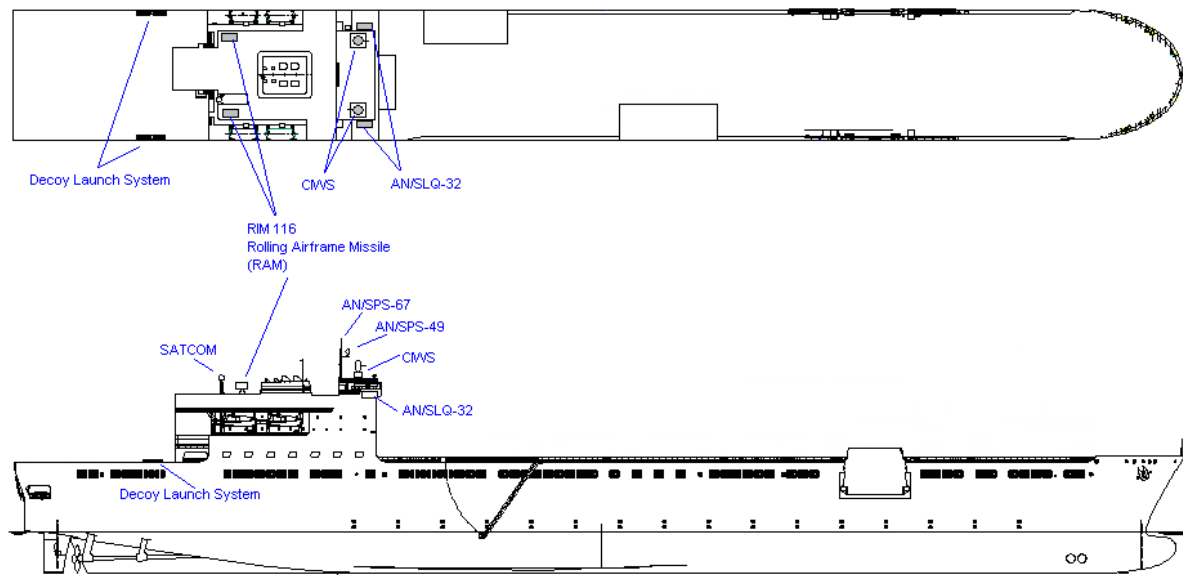
Figure 4. SOF Ship Topside Arrangement
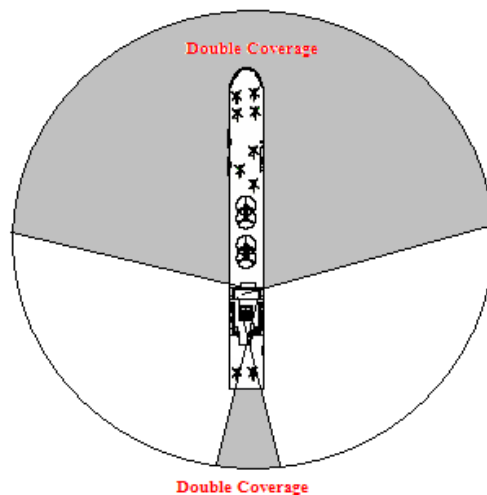
Figure 5. CIWS Arcs of Fire

4.1.3 Propulsion, Electrical, and Auxiliary Systems

The SOF ship design does not alter the engineering plant or any systems in the machinery rooms as shown in Figure 6. The LMSR installed power meets maximum speed and requirements set forth by the sponsor. The propulsion plant has four Colt Pielstick 10 PC4.2V diesel engines (65,160 hp) driving two shafts with controllable pitch propellers. Similarly, most of the electrical distribution system will remain untouched. The LMSR is equipped with four ship's service Wartsilla diesel generators. Each generator delivers 4160V, 60Hz, three phase, and 3500kW. The LMSR electrical power generation system was built with nearly 50% excess capacity. This was done to accommodate redundancy in the event of the loss of a generator. Removing the topside cranes and ramp, as well as the internal deck ramps, will further reduce the demand for electrical loading. The addition of the hotel loads and communication equipment will add to the total loading of the ship, but there should still be sufficient capacity to provide reliability. The emergency diesel generator originally located in the superstructure was moved forward to Hold 1 between frames 20 and 33 above the waterline to maintain emergency response capability. The emergency diesel generator delivers 480 V, 60 Hz, three phase, and 1625 kW.
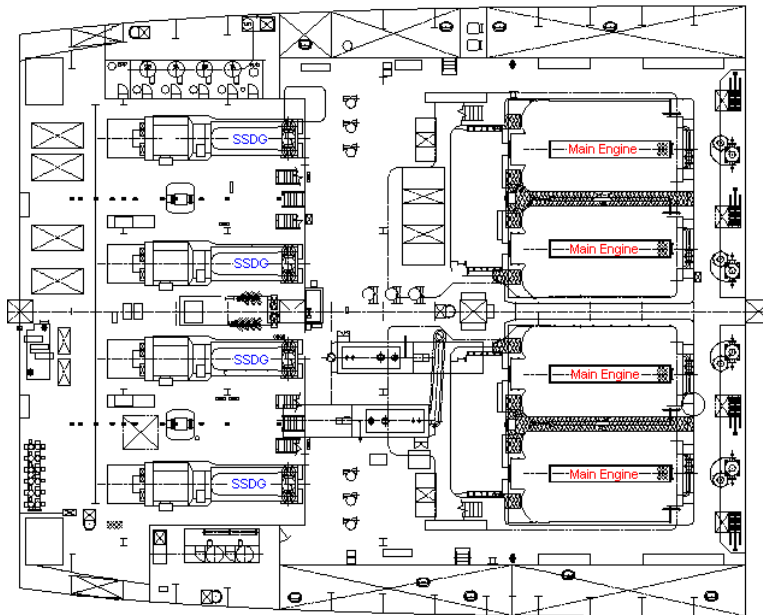
Figure 6. LMSR Middle Level Machinery Arrangement

4.1.4 Survivability and Signatures

The damaged stability criterion for DD-079 is based on flooding 15% of the Length Between Perpendiculars (LBP), whereas the damaged stability criterion for the American Bureau of Shipping (ABS) is based on 3 compartment flooding. ABS requirements were met when the ship was built. Also, flooding of two compartments is more than 15% of the LBP.

There is no need for signature reduction measures since the ship operates as a mobile offshore platform for SOF operations. Additionally, there is no need for design for shock and other combat related survivability standards.

4.1.5 Manning

The LMSR has a base crew of 30 civilian MSC personnel. It was very important to maintain segregation between crew manning and SOF manning so as not to interfere with the ship's routine.

Manning requirements for SOF are classified. The SOF ship does, however, carry a separate air and boat crew. The assumption was made that manning would be similar to that of an LPH for embarked troops. As a result, berthing and messing facilities were provided for 1800 enlisted personnel and 200 officers. SOF will provide additional personnel for all mission related and hotel servicing functions. When the SOF depart the ship, minimal manning will be required. Caretakers will board to perform routine ship maintenance.

4.1.6 Arrangements

4.1.6.1 General Arrangements

Comparison of available area in the spaces considered for modification shows that sufficient space is available. Required space estimates come from approximations made for SOF mission items detailed in the Surface Ship Classification Summary (SSCS) breakdown. Table 13 lists the available space in the modified compartments and the required space for the SOF equipment and components. Appendix C contains a breakdown of the available area versus the area required for the SOF ship.

Table 13. Space Balance

Available Space		
Compartment	Area (ft2)	Volume (ltons)
Total Available	397,413	14,080
Required Space		
Payload Type	Area (ft2)	
Mission Support	170,476	
Human Support	103,496	
Ship Support	40,007	
Ship Machinery System	52,167	
Tanks		Volume (ltons)
Freshwater Tanks		1,231
Seawater Tanks		2,173
Diesel Oil Tanks		4,361
JP-5		1,043
Miscellaneous Tanks		456
Lube Oil Tanks		134
Total Required	366,146	9,398

4.1.6.2 Inboard Profile

4.1.6.2.1 Deck Plans

Due to a significantly different role, the SOF ship does not require the large stores handling apparatus of the LMSR. The two large cranes and all other deck obstructions were removed from the A deck to create a flight deck. The structural support for the flight deck is actually 3 feet higher than the original A deck, thus allowing the creation of catwalks within the original hull structure of the ship. This is important because it allows the SOF ship to retain its PANAMAX capability. The catwalks were included to allow for safe personnel movement around the flight deck, aircraft servicing and fueling stations, and damage control casualties.

Flight deck areas are located both forward and aft of the deckhouse. The primary landing areas are located forward of the deckhouse. Two aircraft elevators are located in the forward flight deck area. The starboard elevator is located near midships, and the port elevator is just forward of the deckhouse. These are sized to accommodate the large helicopters that could be utilized by a SOF group. A smaller secondary landing area is located directly aft of the deckhouse. There is no direct access to the aircraft elevators from this area, but there is a small hangar built into the rear of the deckhouse. This area is large enough to support major maintenance to one small helicopter.

The ability to create a large flight deck was a primary concern when selecting a platform for the SOF ship. Figure 7 shows scale comparisons of CVN68, LMSR (SOF ship configuration), and LHD1. The reconfiguration of the SOF ship provides a flight deck area comparable to that of the LHD.

| CVN68 | LOA:1092 ft | B:134 ft | Flt Dk:254 ft |

| LMSR/SOF Ship | LOA:951 ft | B:106 ft |

| LHD1 | LOA:844 ft | B:106 ft | Flt Dk:106 ft |
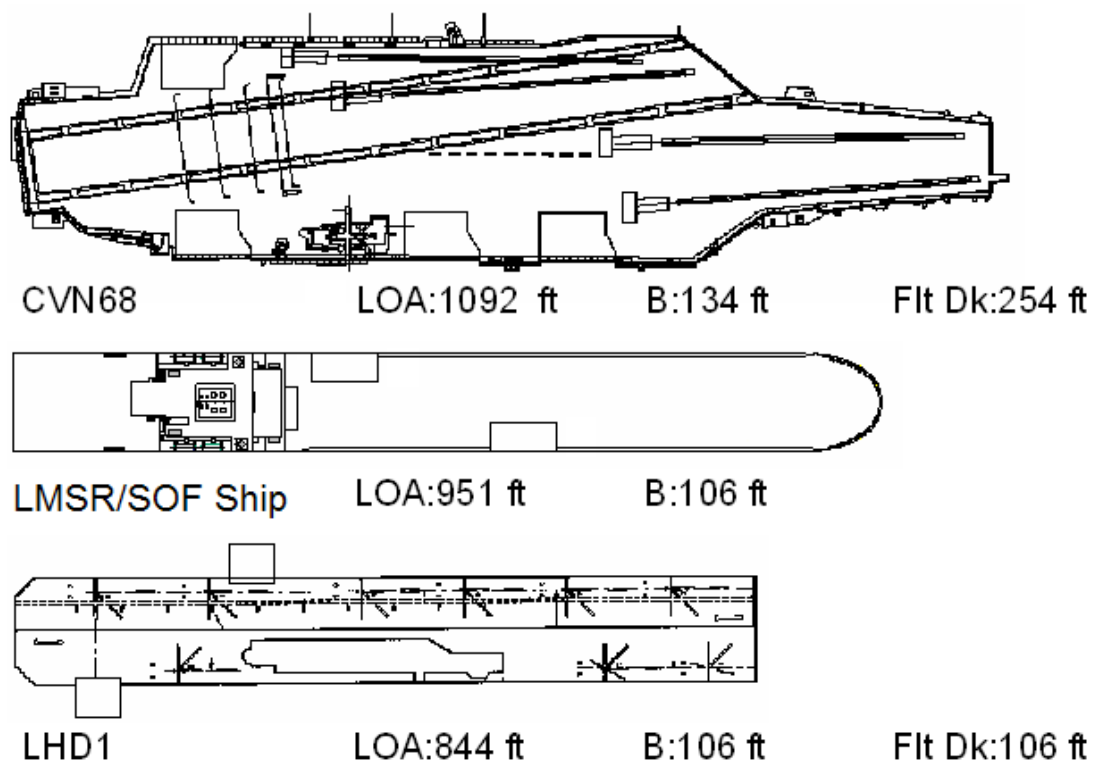
Figure 7. Topside Arrangement Comparison

The B deck is the hangar bay. Figure 8 shows a potential arrangement for decks A through E. The spaces contain descriptions of general departments and crew comforts found aboard a typical navy vessel, but do not contain all allocated spaces. For a complete space

allocation breakdown, see Appendix C. Aircraft access to the hangar bay is via the two elevators described above. Forward of the elevators are boat ramps on both the port and starboard sides, the center of which is at frame 37. Inboard of the ramps are storage locations for a number of helicopters. Helicopters can be stored between frames 50 and 92. At frame 58, a cargo elevator is located centerline which connects to the F deck and all intervening decks. Between frames 92 and 96 the machinery exhaust stacks are found centerline; these stacks extend from the C deck to the top of the deckhouse. Between frames 99 and 113, additional helicopters can be stored.

The C deck contains departmental areas, officer country, and briefing rooms. The ship's store and barber are located between frames 20-33. Medical/Dental and the library/chaplain (frames 33 and 50), briefing rooms and air/weapons departments (frames 50-65), officer country and SCIF rooms (frames 65-85), CIC/Ops and Radio/Crypto spaces (frames 85-99), and supply and personnel departments (frames 99-113) are located on opposite sides of centerline between the given frames. The steering gear is positioned between frames 113 and 117.

The D deck contains the gym, crew berthing, crew galley and mess, machinery room and auxiliary machinery room. The gym is located between frames 20-33. Crew berthing (frames 33 and 50), crew galley and mess (frames 50-65), crew berthing (frames 65-85), machinery room (frames 85-99), and auxiliary machinery room (frames 99-113) are located on opposite sides of centerline between the given frames.

The E deck contains EDG room, general stores, reefer stores, food stores, MAA/Brig, armory, machinery room and auxiliary machinery room. The EDG room is located between frames 20-33. General stores (frames 33 and 50), reefer stores and food stores (frames 50-65), MAA/Brig and armory (frames 65-85), machinery room (frames 85-99), and auxiliary machinery room (frames 99-113) are located on opposite sides of centerline between the given frames.

The F deck contains general stores, weapons magazine, machinery room and auxiliary machinery room. The general stores are located between frames 33-50 weapons magazine (frames 50-85), machinery room (frames 85-99), and auxiliary machinery room (frames 99-113) are located on opposite sides of centerline between the given frames.
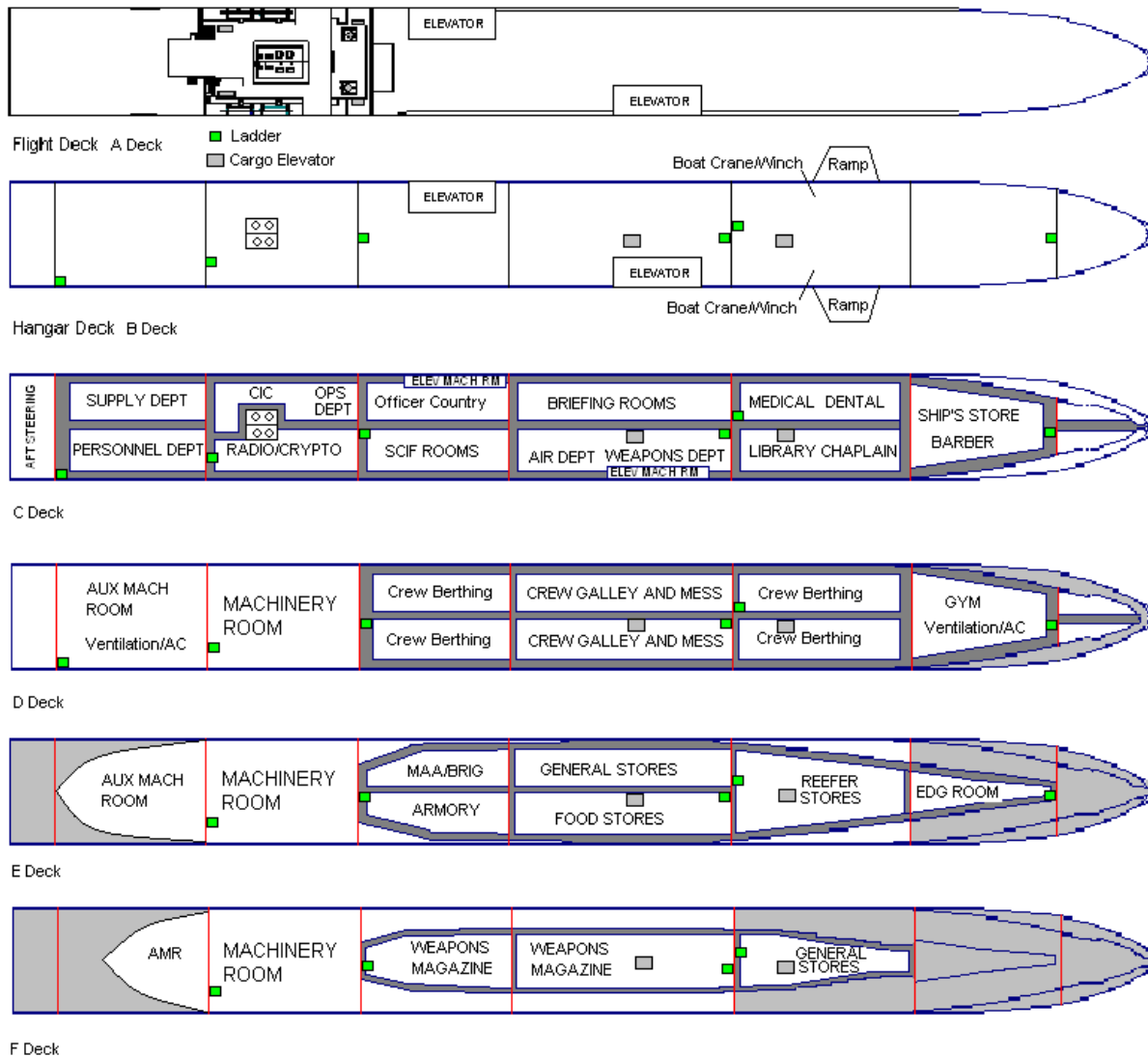
Figure 8. SOF Ship Deck Layouts

4.1.6.2.2 Deckhouse Plans

The deckhouse is largely unchanged. The emergency diesel generator was relocated from the deckhouse to the most forward space on the E Deck. This allowed for creation of Command and Control (02 and 03 levels) with easy access to passageways. The 04 level is now primary flight control. The licensed and unlicensed civilian crew berthing remains in the deckhouse. The deckhouse plans are illustrated in Figures 9a through 9f.
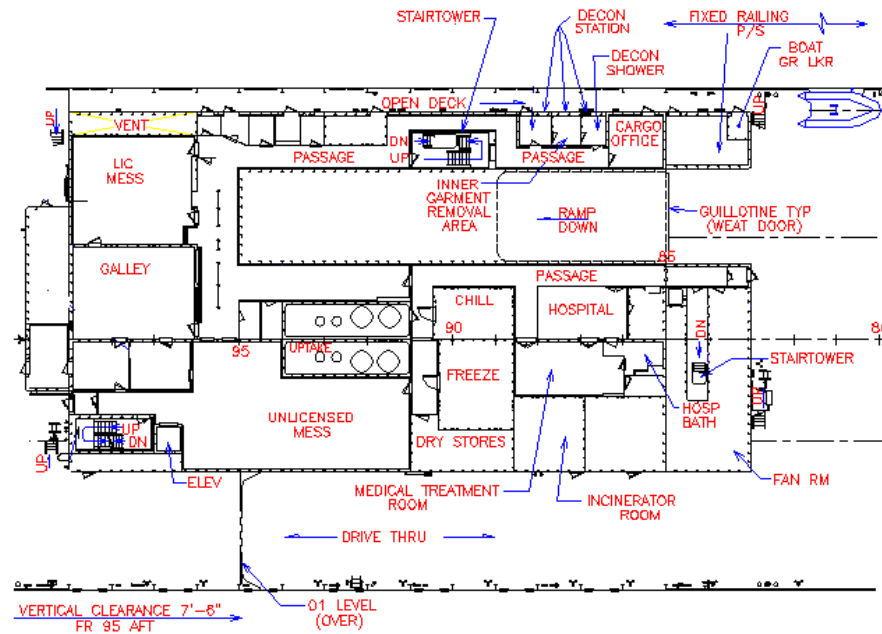
Figure 9a. Deckhouse Layout-A Deck
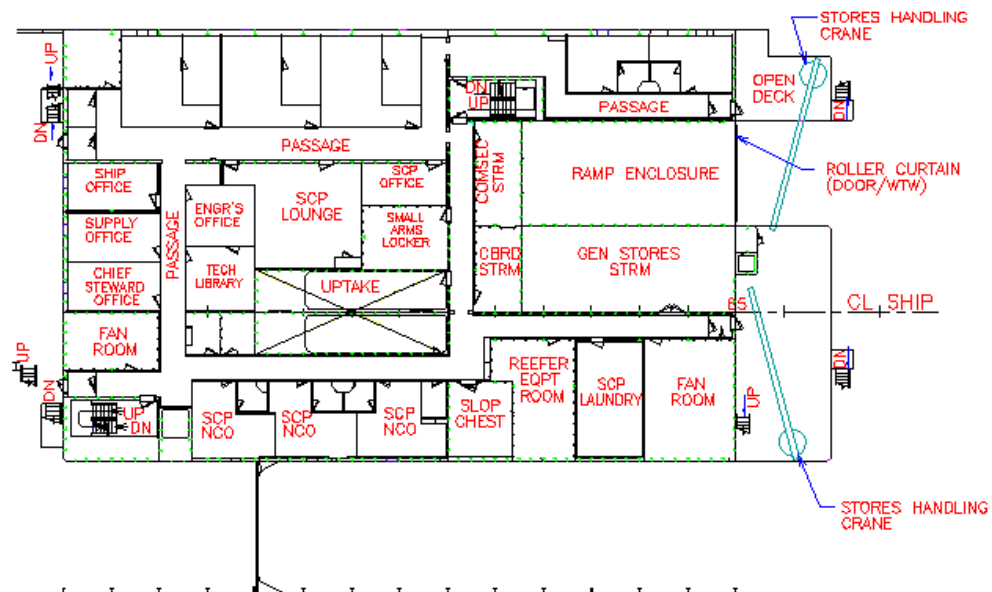
Figure 9b. Deckhouse Layout-01 Level
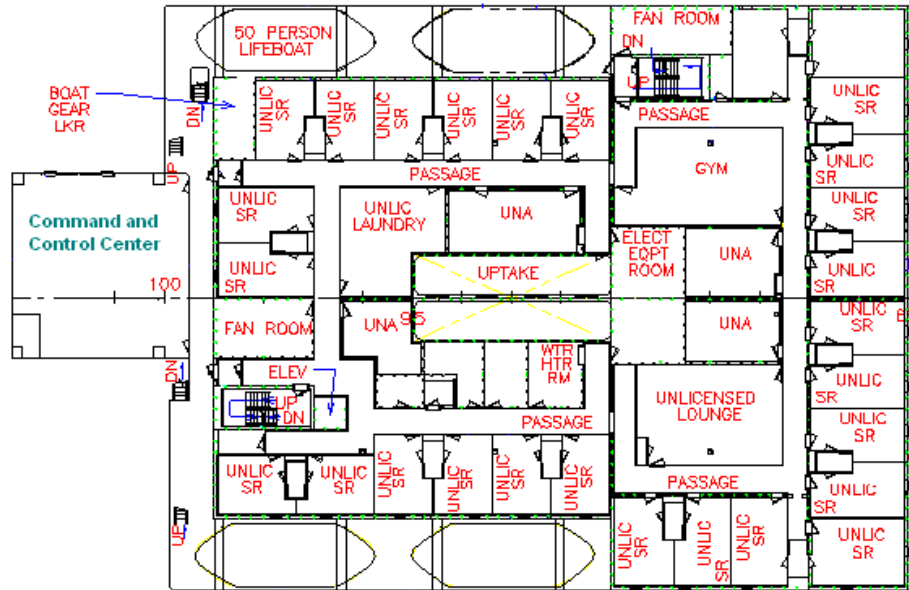
Figure 9c. Deckhouse Layout-02 Level
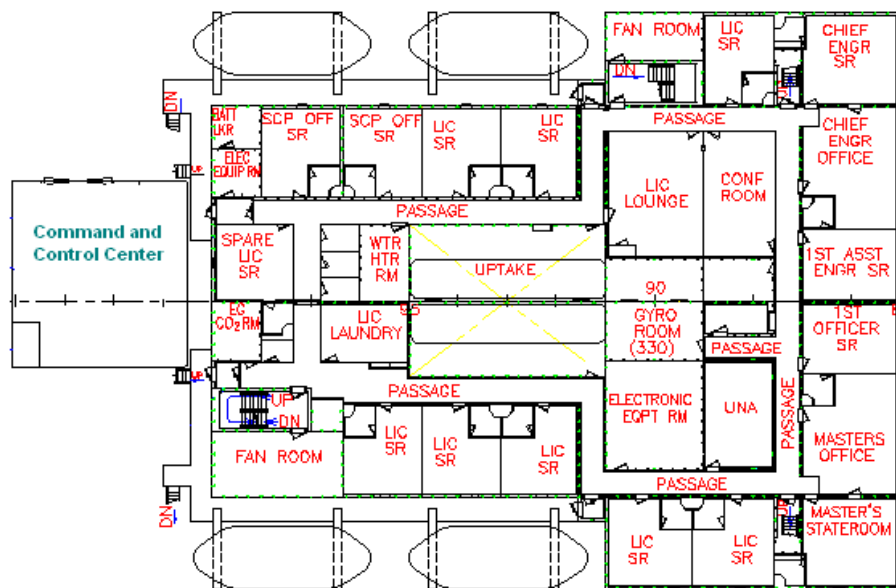
Figure 9d. Deckhouse Layout-03 Level
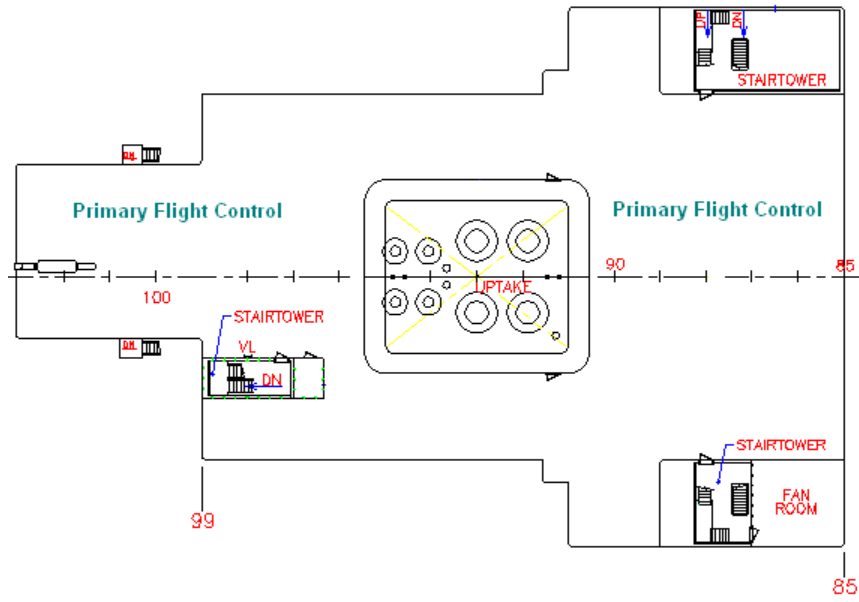
Figure 9e. Deckhouse Layout-04 Level
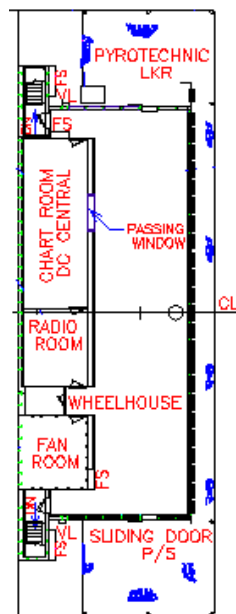
Figure 9f. Deckhouse Layout-05 Level

4.1.6.3 Tank Layouts

The tank layouts are as depicted in Figure 10 below. Diesel oil (4928 ltons) and seawater ballast (6304 ltons) are well distributed throughout the ship. JP-5 (1600 ltons) for the helicopters is located just forward of frame 65 in six tanks outboard of centerline and

extending to the hull. Freshwater (1381 ltons) is located in six tanks just aft of frame 99. Lube oil and miscellaneous service tanks contain 136 and 466 ltons respectively.
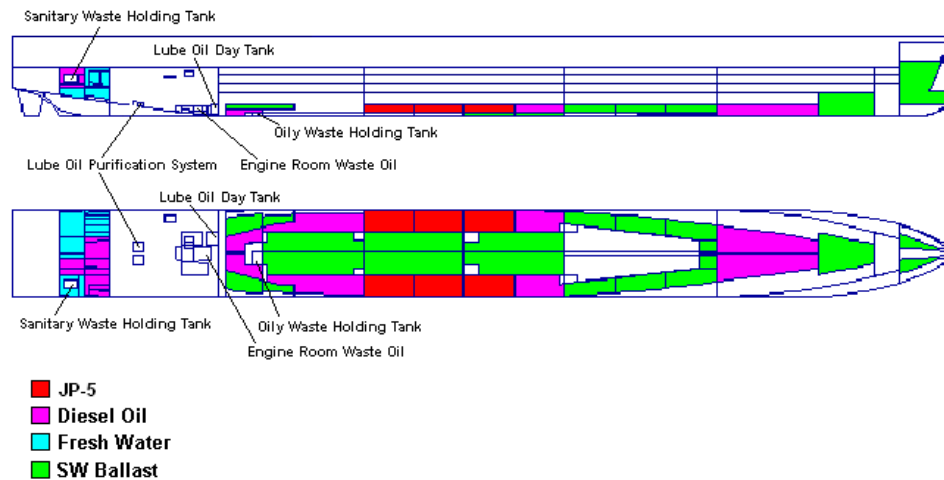
Figure 10. SOF Ship Tank Layouts

4.1.7 Structural Design

4.1.7.1 Midship Section Concept Design

There are two classes of LMSR ships, the Bob Hope class built by Avondale Industries and the Watson class built by National Steel Shipbuilding Company (NASSCO). The design of the midship section was largely based on the section generated by the POSSE Watson class files. The Bob Hope class files were unavailable in Version 2 of POSSE. As a result, the Watson class midship section was modified to reflect the differences between the classes. The greatest difference is the A-B deck configuration. The Watson class ships have a fixed A-B deck, whereas the Bob Hope class ships have a hoistable A-B deck. The hoistable A-B deck made the Bob Hope class more desirable for the SOF platform because it simplifies the creation of a hangar deck. Figure 11 shows the structural design of the midship section defined using POSSE after modifications were made. The strength of the new design was tested using the POSSE Intact and Damaged Stability Modules.
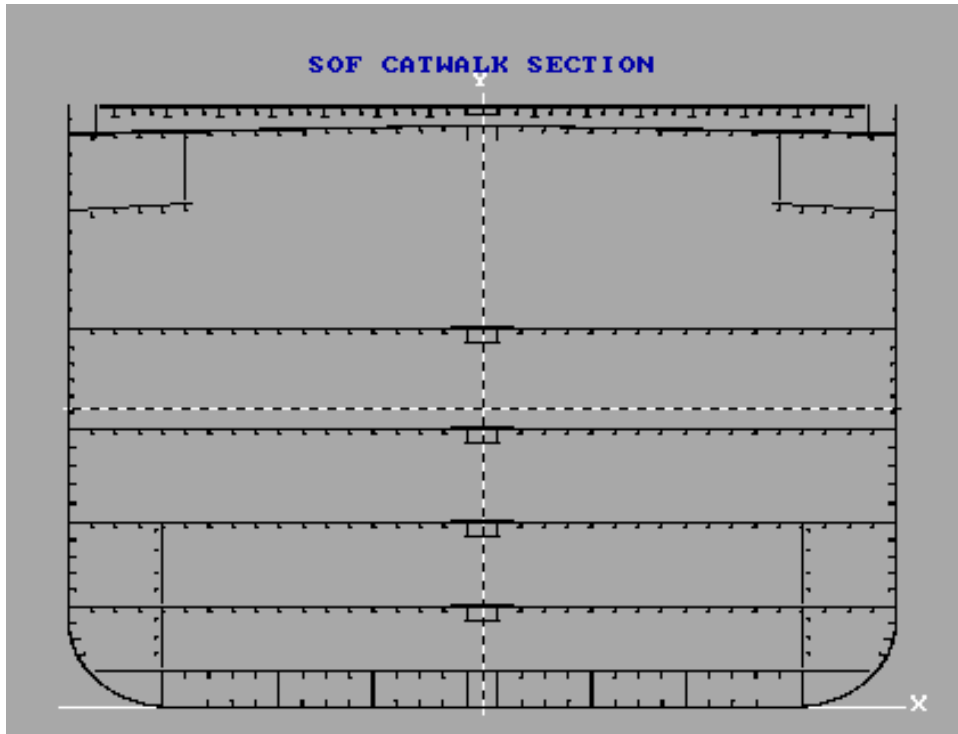
Figure 11. SOF Ship Midship Section Structure

4.1.7.2 Flight Deck Modifications

The SOF ship design will not change the essential LMSR structural design and will add a flying deck three feet above the current A or Weather deck. The flight deck will be built in modular sections for ease of installation and for cost minimization. The flight deck was built four feet narrower than the full beam of the A Deck. This provided space for catwalks within the original hull structure of the ship. The catwalks extend from Frame 28 to Frame 80, with exception of the elevators which run to the hull of the ship. This catwalk design is important because it allows the SOF ship to retain its PANAMAX capability. The catwalks were included to allow for safe personnel movement around the flight deck, helicopter fueling stations, and damage control casualties. Also, drains were installed around the flight deck and catwalks for removal of green water on deck.

4.1.7.3 Section Properties

The properties of the new sections lower the center of gravity as well as the section total area and moments of inertia.   Overall, the properties of the section modulus remain unaffected. Table 14 makes a comparison between the values of the LMSR and the SOF ship mid-ship section.

Table 14. LMSR to SOF Ship Comparison

	LMSR	SOF
Area	$.76 \times 10^4$ [in^2]	1.3×10^5 [in^2]
I$_{xx}$	8.9×10^6 [in^2-ft^2]	1.6×10^7 [in^2-ft^2]
Dist. To upper extreme fiber	47.48 [ft]	47.31 [ft]
Section Modulus Upper Flg	1.8×10^5 [in^2-ft]	3.3×10^5 [in^2-ft]
Dist. To lower extreme fiber	48.65 [ft]	46.26 [ft]
Shear Area y	2027.4 [in^2]	4345.5 [in^2]
I$_{yy}$	2.7×10^6 [in^2-ft^2]	1.5×10^7 [in^2-ft^2]
Dist. To left extreme fiber	29.28 [ft]	52.95 [ft]
Section Modulus Left Flg	9.2×10^4 [in^2-ft]	2.9×10^5 [in^2-ft]
Dist. To right extreme fiber	27.51 [ft]	52.95 [ft]
Section Modulus Right Flg	9.8×10^4 [in^2-ft]	2.9×10^5 [in^2-ft]
Shear Area x	5681.1 [in^2]	9496.5 [in^2]

From the table analysis, it can be predicted that the converted ship sections are going to have similar, if not lower, due to increased cross-sectional area, stresses over its structure when compared to the LMSR under the same applied loads.

4.1.8 Weights and Margins

4.1.8.1 Weight and Stability Modifications for Lightship

The total weight removed from the LMSR by the deletion of all the elements stated above was 1,452.02 ltons. The weight added for conversion was 7,421.54 ltons. This included a weight margin of 10% which was incorporated into each SWBS weight breakdown. The main contribution for the added weight came from the flying deck structure, which is symmetric with respect to the ship's centerline and from the C4I equipment located

in both the modified superstructure and C deck configuration. A lightship weight summary is presented in Table 15.

Removing the topside cranes, the aft ramp, the topside fan rooms, and relocating the emergency diesel generator contributed to lowering the VCG. From the stability standpoint the weight removed has a center of gravity well above the VCG, near amidships and close to the centerline. Its values were:

- Removed w_{vcg} BL: 95.96 ft.
- Removed w_{lcg} FP: 712.86 ft
- Removed w_{tcg} CL: 0.93 ft.

Adding berthing accommodations, weapons magazines, increased ventilation and air conditioning systems, and relocating the emergency diesel generator also lowered the VCG. The addition of the two elevators contributed to moving the LCG forward. The values obtained were:

- Added w_{vcg} BL: 58.09 ft.
- Added w_{lcg} FP: 317.36 ft
- Added w_{tcg} CL: 2.28 ft.

The final stability conditions produce a TCG of 0.65 ft to starboard, an LCG of 441.7 ft, and a KG of 45.67 ft. The results are very similar to the LMSR Lightship conditions, and as such fulfill all the stability requirements. The lightship weight distribution can be seen in Figure 12. The final stability parameters and a comparison between the original and modified ship are shown in Table 15.
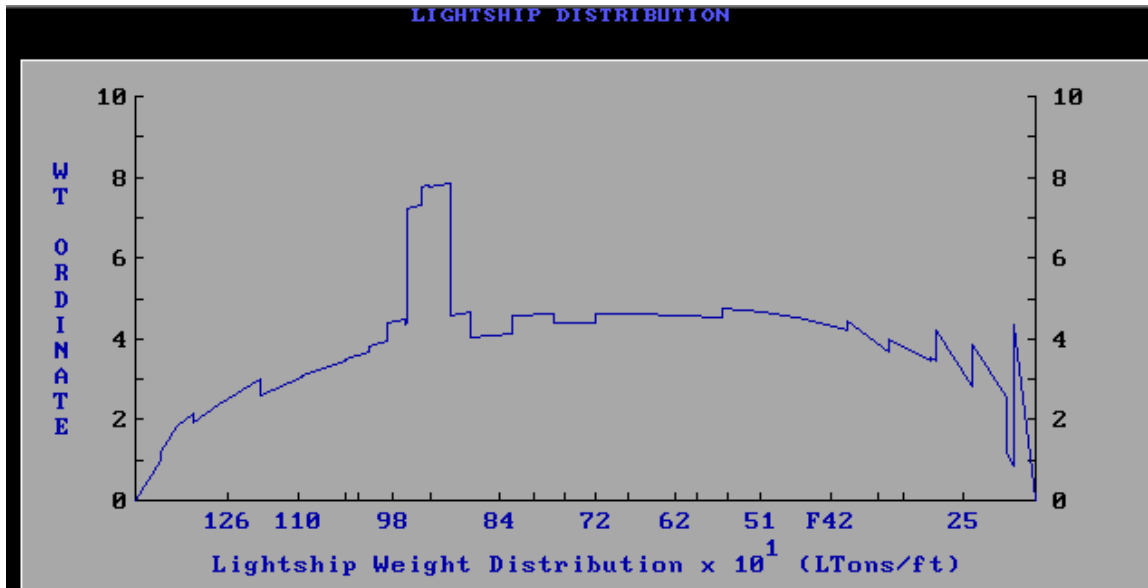
Figure 12. Lightship Weight Distribution

Table 15. LMSR & SOF Ship Stability Parameters Comparison

	LMSR	SOF
Lightship Displacement	33,026 Ltons	37,681 Ltons
Lightship KG	44.47 ft	45.67 ft
Lightship LCG	496.87 ft.	441.70 ft.
Lightship TCG	0.32 ft.	0.65 ft.

4.1.8.2 Tank Modifications

To provide aircraft refuel capacity, six DO side tanks were converted to JP-5. The total JP-5 capacity is 1,043 ltons. For comparison purposes, the LHD carries approximately 1,232 ltons of JP-5 on board. Similarly, the SOF ship has 4,619 ltons of diesel oil, whereas an LHD carries approximately 6,000 ltons. The ship's maximum range will be reduced slightly due to the DO tanks modification, however, because the full load displacement decreased by approximately 14,000 ltons, the SOF ship should still have a maximum range of 10,000+ nm. The full load draft also decreased by approximately 9 feet, resulting in less hull resistance on the ship. This further increases the range of the SOF ship. This decrease in draft does not, however, disturb any seawater inlets or outlets for the machinery room equipment.

4.1.8.3 Weight Summary

The full load and minimum operating conditions were evaluated for both intact and damaged stability. Table 16 lists a breakdown of weights for each of these conditions.

The full load condition assumes the following:

- One empty fuel tank
- Compensated ballast to account for empty fuel tank if necessary
- Fresh water reduced by 1/3
- Crew and effects remain unaffected
- Misc. Related Expenditures remain unaffected
- Ships Stores remain unaffected.

The minimum operating condition assumes the following:

- Total fuel reduced by 2/3
- Compensated ballast to account for empty fuel tank if necessary
- Fresh water reduced by 1/3
- Crew and effects remain unaffected
- Misc. Related Expenditures reduced by 2/3
- Ships Stores reduced by 2/3.

Source: Stability and Buoyancy: DDS 079-2

Table 16. LMSR & SOF Ship Stability Parameters Comparison

Weight (ltons)	Full Load	Minimum Operating
Lightship Weight	37,681	37,681
Crew and Effects	360	360
Mission Related Expenditures	120	40
Helo	127	127
Boats	117	117
Ships Stores	678	224
Medical	19	19
Dry Stores	260	86
Freeze Stores	180	59
Fuels and Lube Oil	6,274	4,289
Fresh Water	925	455
Clean Ballast	1,741	2,687
Miscellaneous	456	307
Total Displacement	48,937	46,452

The tank weight summary for both the full load and the minimum operating condition is included in Appendix D.

4.1.9 Intact Strength and Stability Analysis

The intact stability analysis was conducted using the POSSE modified Watson class files. Every loading condition described previously was tested under the next three different conditions:

- Still water
- 100 knots wind
- High Speed Turn. 24 knots, Radius of turn 3000 ft.

The results were satisfactory for every case. Table 17 shows the stability results for the cases described. It is important to highlight that the SOF ship model has a better stability performance than the Watson does for the three conditions described. Figure 13 shows the worst case GZ curve, the high speed turn for the minimum operating condition.

Table 17. Intact Stability results

	Disp. [ltons]	KG [ft]	Mean Draft [ft]	Trim [ft]	GZ Max [ft]	Heel Angle Still Water	Heel Angle 100kt wind	Heel Angle High Speed Turn	Propeller Immersion
Full Load	48,937	39.98	27 ft 9.7 in	0.20 A	8.00 @ 38.4º	0.1º Port	0.9º	2.2º	114 %
Min Op Cond	46,452	40.92	26 ft 8.3 in	0.35 A	7.13 @ 38.3º	0.4º Stbd	1.4 º	2.8 º	109 %

EFFECT on STABILITY of HIGH SPEED TURNING
(per U.S. Navy DDS079-1)
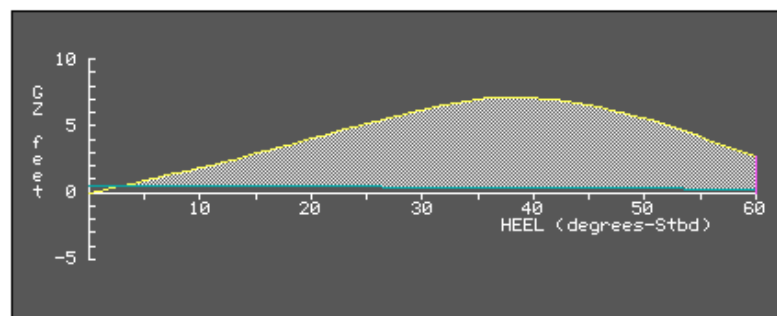
	Available	Required
Angle of Heel	2.8 deg	15.0 deg
Heeling Arm Lc	0.47 ft	
Maximum Righting Arm	7.13 ft	0.78 ft
Total Righting Area	264.2 ft-deg	
Reserve Righting Area	241.7 ft-deg	105.7 ft-deg

Figure 13. GZ Curve for Intact Stability in Stillwater

The POSSE Intact Stability Module does not simulate the ship behavior in waves or under severe weather conditions. The Salvage Module is used for this purpose as well as for assessing damage due to flooded compartments. For the non-damaged case, the procedure is to damage a small compartment that will not affect stability during hogging and sagging cases so that wave and wind conditions can be applied. The hull strength was also tested using the POSSE Intact Module for stillwater conditions indicated in the stability analysis. The stresses were found to be very close for both the full load and minimum operating conditions. The hogging condition has the highest stresses, and they are significantly higher than the sagging conditions. This can be attributed a higher loading density distribution in the fore and aft parts of the ship to maintain trim and stability. Table 18 shows a summary of the strength analysis for the two loading cases analyzed. Figure 14 shows full load shear and bending stresses. A complete report of all intact stability case results and diagrams are included in Appendix E.

Table 18. Stress Comparison

Sea Condition	Stress (ksi)	Full Load	Minimum Operating Condition
Stillwater	Shear	-3.47	-3.53
	Bending, at Deck	7.72	7.85
	Bending, at Keel	-8.46	-8.62
Hogging	Shear	-5.36	-5.31
	Bending, at Deck	14.95	15.09
	Bending, at Keel	-16.23	-16.31
Sagging	Shear	-1.70	-1.70
	Bending, at Deck	-2.72	-2.32
	Bending, at Keel	2.74	2.34
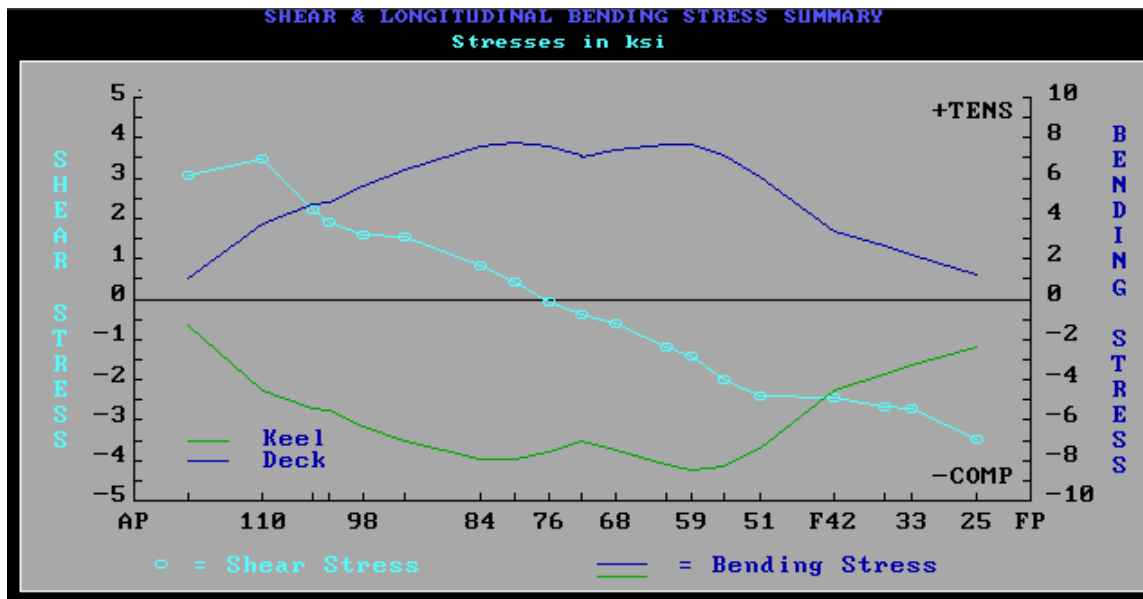
Figure 14. Full Load Shear & Bending Stresses for Intact Stability in Stillwater

4.1.10 Damaged Stability and Strength Analysis

4.1.10.1 Damaged Stability Analysis

The Salvage Module is used to assess the effects of flooding compartments. Large compartments are flooded to check the worst condition that the ship can withstand. The wave height used in this analysis was $1.1 \cdot \sqrt{LBP}$. The wavelength is the LBP and its crest position was defined to test stillwater, hogging, and sagging conditions. Damaged stability was assessed for three cases: damage forward, amidships, and aft. The limiting case was two compartment flooding for each section. The analysis considered the same loading cases defined previously. The wave and wind settings were:

- Wave height: 32.7 feet
- Wave length: 884 feet
- Wind speed: 100 knots

The stability results for full load and minimum operating conditions are listed in Tables 19 and 20 respectively. The stability values show that the SOF ship is extremely stable under extreme conditions. The worst case condition occurs with damage to the midship section during a hogging condition. Overall, the ship will experience its worst heel angle of 5.2

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degrees while hogging during minimum operating conditions. Figures 15 and 16 show the worst case GZ curves for the damaged full load and minimum operating conditions under wind-wave effects.

Table 19. Damaged Stability Results for Full Load Case
Under Severe Wind and Wave Conditions

Condition		GMt [ft]	GZ max [ft]	Static Heel Angle [deg]	Wind Heel Angle [deg]	Range of positive GZ [deg]	Freeboard to margin line [ft]
Stillwater	Damage Fwd	11.16	7.19 @37.0Sº	0.1Sº	0.9Sº	> 59.9 º	53.65
	Damage Mid	10.34	4.83 @32.3Sº	0.6Sº	1.1Sº	> 59.4 º	41.78
	Damage Aft	8.12	6.11 @37.9Pº	0.1Pº	1.4Pº	> 59.9 º	62.62
Hogging	Damage Fwd	7.85	5.29 @39.0Sº	0.1Sº	1.6Sº	> 59.9 º	67.08
	Damage Mid	6.55	2.31 @35.7Sº	1.0Sº	1.7Sº	> 58.0 º	39.22
	Damaged Aft	7.61	5.22 @38.9Pº	0.1Pº	1.8Pº	> 59.9 º	64.44
Sagging	Damage Fwd	17.28	7.90 @35.1Sº	0.0Sº	0.4Sº	> 60.0 º	35.43
	Damage Mid	15.52	5.98 @32.5Sº	0.4Sº	0.8Sº	> 59.6 º	39.91
	Damaged Aft	10.40	5.68 @37.5Sº	0.8Sº	1.6Sº	> 59.2 º	46.88
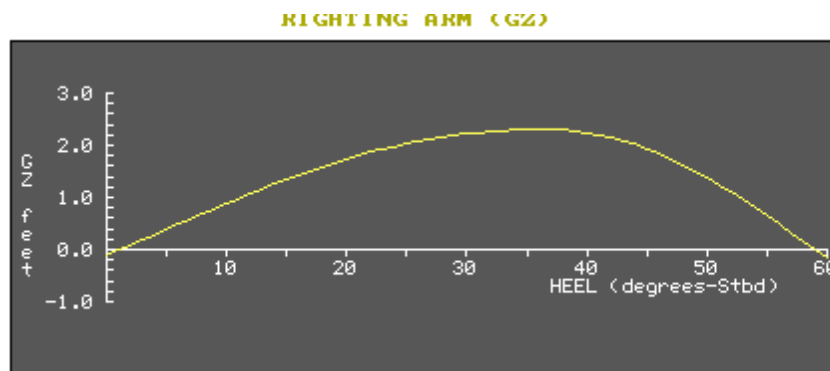
Figure 15. GZ Curve for Damaged Full Load under Wind-Wave Conditions

Table 20. Damaged Stability Results for Minimum Operating Case
Under Severe Wind and Wave Conditions

Condition		GMt [ft]	GZ max [ft]	Static Heel Angle [deg]	Wind Heel Angle [deg]	Range of positive GZ [deg]	Freeboard to margin line [ft]
Stillwater	Damage Fwd	10.32	6.53 @36.4Sº	0.4Sº	1.4Sº	> 59.6 º	53.59
	Damage Mid	9.09	4.25 @32.1Sº	2.5Sº	3.1Sº	> 56.5 º	42.90
	Damage Aft	7.09	5.28 @37.4Pº	0.6Pº	2.3Pº	> 59.4 º	63.15
Hogging	Damage Fwd	6.85	4.67 @38.0Sº	0.6Sº	2.5Sº	> 59.4 º	68.52
	Damage Mid	6.19	1.65 @34.8Sº	4.1Sº	5.2Sº	> 49.5 º	39.38
	Damaged Aft	6.44	4.49 @37.9Pº	0.7Pº	2.9Pº	> 59.3 º	65.76
Sagging	Damage Fwd	17.42	7.29 @34.1Sº	0.2Sº	0.6Sº	> 59.8 º	35.97
	Damage Mid	15.22	5.40 @31.7Sº	1.5Sº	1.9Sº	> 58.5 º	41.86
	Damaged Aft	8.88	4.98 @36.4Sº	0.3Sº	1.3Sº	> 59.7 º	48.59
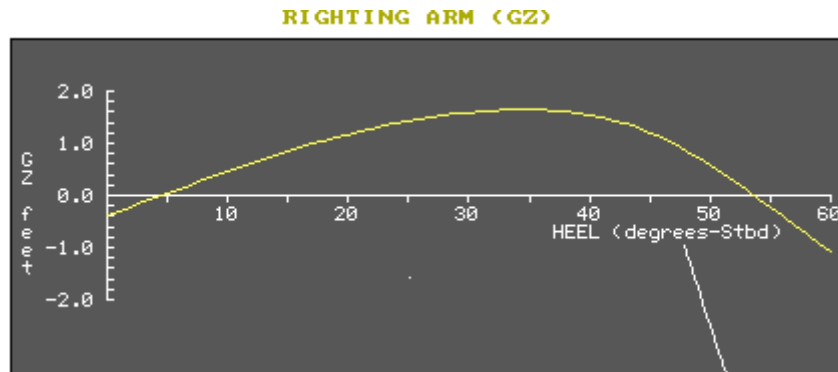
Figure 16. GZ Curve for Damaged Minimum Operating under Wind-Wave Conditions

4.1.10.1.1 LMSR and SOF Ship Stability Comparison

Table 21 compares the stability results for the SOF ship and LMSR when operating under similar full load conditions. The SOF ship has better stability performance than the LMSR. Removal of the topside cranes compensates for the addition of the flight deck. This can be seen from the GM results for the SOF ship. The slight difference in GM makes the modified LMSR ship better in stability than the original Watson class ship.

Table 21. Weight and KG Comparison

		LMSR	SOF
Displacement		62,069 ltons	48,937 ltons
KG		45.29 feet	39.98 feet
Draft, Amidships		37 ft	27.8 ft
Trim		0.99 feet	0.20 feet
GM_t (corrected)		7.61 feet	11.94 feet
GZ_{MAX}		5.61 feet	8.00 feet
Damage Forward	Initial GM_t	7.14 feet	11.16 feet
	GZ_{MAX}	4.88 feet	7.19 feet
Damage Amidship	Initial GM_t	8.99 feet	10.34 feet
	GZ_{MAX}	2.96 feet	4.83 feet
Damage Aft	Initial GM_t	3.53 feet	8.12 feet
	GZ_{MAX}	3.24 feet	6.11 feet

4.1.10.2 Damaged Strength Analysis

The hull strength was also tested using the POSSE Salvage Module under the same loading conditions indicated in the stability analysis. The worst case scenario was found for the hogging, full load condition operating under extreme wind and wave conditions. Tables 22 and 23 show a summary of the strength analysis for the two loading cases analyzed. Figures 17 and 18 show the worst case shear and bending stress curves for the damaged full load and minimum operating conditions under wind-wave effects. A complete report of all damaged case results and diagrams are included in Appendix F.

Table 22. Damaged Stability Results for Full Load Case Under Severe Wind and Wave Conditions

Condition		Shear Stress [ksi]	Deck Bending Stress [ksi]	Keel Bending Stress [ksi]
Stillwater	Damage Fwd	-4.95	11.42	-12.63
	Damage Mid	2.71	3.38	-3.93
	Damage Aft	-3.51	7.70	-8.52
Hogging	Damage Fwd	-5.49	15.28	-16.62
	Damage Mid	4.11	7.09	-7.68
	Damaged Aft	-4.61	13.13	-14.41
Sagging	Damage Fwd	-5.44	6.67	-7.74
	Damage Mid	3.41	-8.63	9.43
	Damaged Aft	-2.44	3.76	-4.12
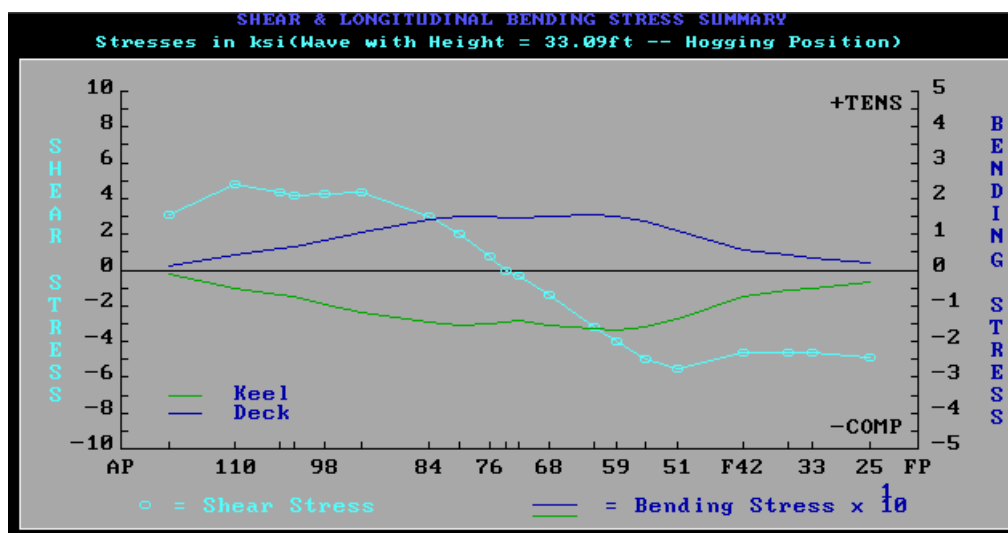
Figure 17. Damage Full Load Shear & Bending Stresses, Hogging

44

Table 23. Damaged Stability Results for Minimum Operating Case Under Severe Wind and Wave Conditions

Condition		Shear Stress [ksi]	Deck Bending Stress [ksi]	Keel Bending Stress [ksi]
Stillwater	Damage Fwd	-4.95	11.76	-13.00
	Damage Mid	2.91	7.12	4.51
	Damage Aft	-3.59	8.08	-8.88
Hogging	Damage Fwd	-5.55	15.68	-16.98
	Damage Mid	3.90	14.07	10.84
	Damaged Aft	-4.67	13.55	-14.77
Sagging	Damage Fwd	-5.43	6.85	-7.92
	Damage Mid	3.32	-8.40	9.19
	Damaged Aft	-2.51	3.80	-4.13
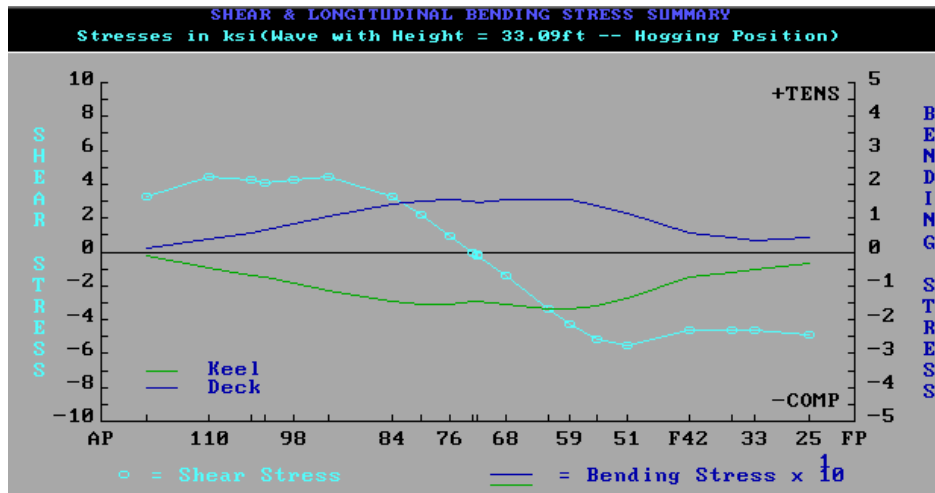
Figure 18. Damage Minimum Operating Shear & Bending Stresses, Hogging

4.1.10.2.1 Comparison of LMSR and SOF ship

The strength properties of the LMSR and SOF ship are compared below in Table 24, as determined using POSSE. The SOF ship has a significantly better performance during hogging conditions, while the sagging conditions are nearly twice as high. Overall, the SOF ship is structurally sound.

Table 24. LMSR-SOF Stress Comparison

Load Condition	Sea Condition	Stress (ksi)	LMSR	SOF
Full Load	Hogging	Shear	8.84	-5.49
		Bending, at Deck	34.25	15.28
		Bending, at Keel	-24.77	-16.62
	Sagging	Shear	1.48	3.41
		Bending, at Deck	-4.72	-8.63
		Bending, at Keel	4.14	9.43

The ship has a satisfactory performance for all the cases analyzed and presents better stability and structural performance than the original LMSR. The results obtained for both the Intact and Damaged Conditions indicate, from a stability standpoint, that the conversion is feasible and will have good performance in all weather conditions.

4.2 Performance Analysis

4.2.1 Mission

The primary mission of the SOF ship is to provide a platform for SOF operations. The SOF ship will act as a base of operations for the planning and execution of SOF missions ashore (insertion, close air support, extraction) and afloat (naval interdiction, capture of assets such as oil platforms).

4.2.1.1 Aircraft Operations

The SOF ship will provide a platform for rotary wing and VTOL/STOVL air operations in support of SOF missions.

4.2.1.2 Boat Operations

The SOF ship can act as a base for SOF boats, such as Navy Special Boat Units. The hangar deck can accommodate a 12 medium-size patrol or assault boats which can be launched by crane from the forward hangar deck ramps. SOF typically use RIBs that are 36 feet in length. Therefore, space availability for boat operations should be adequate.

4.2.2 Survivability and Signatures

The only major changes to the SOF ship will be the removal of the large deck cranes and the rear roll-on roll-off ramp, so it will retain the signature of the Bob Hope class LMSR. The survivability will be significantly upgraded with the addition of the Ship Self-Defense System (SSDS). The SSDS is comprised of the RIM-116 Rolling Airframe Missile (RAM), the Close-In Weapon System (CWIS), and the decoy launch system. The SSDS integrates the AN/SPS-49, the AN/SPS-67 surface search radar, the AN/SLQ-32 sensor, and the CIWS

search radar into a cohesive ship defense system. The SSDS provides a high level of protection against anti-ship missiles and aircraft.

4.2.3 Seakeeping and Maneuvering

4.2.3.1 Natural frequencies

The resonant roll and pitch frequencies were computed using standard naval architecture equations and the ship's dimensions as calculated by SWAN. All calculations are shown in Appendix G. A Pierson-Moskowitz sea spectrum was then used to relate the resonant periods to significant wave heights. These results gave a rough indication of the motion of the ship. The results are summarized in Table 25.

Table 25. Calculated Resonant Data

k_{roll}	5.33 m
k_{pitch}	46.08 m
k_{yaw}	15.787 m
ω_{roll}	0.17 Hz
ω_{pitch}	0.225 Hz
T_{roll}	5.876 sec
T_{pitch}	4.454 sec

The motions of the ship have vertical components (heave, pitch and roll) that can create serious problems, thus causing the ship to behave like a damped spring-mass system. In order to understand the nature of the ship response to sinusoidal waves, it is useful to derive the natural frequencies for heave and pitch. For ship motions, the maximum motions do not necessarily occur around synchronism. The magnitude of the exciting forces and the coefficients in the equations of motion all depend on the encounter frequency. Encounter frequency can depend on various parameters, including wavelength, ship speed, and heading. Therefore, at low frequencies, resonance can occur at very short wavelengths with a very small exciting force. However, at higher forward speeds, the frequency of encounter can cause resonance to fall within the range of wavelengths where the exciting forces are large. The T-AKR 300 Bob Hope class hull currently has good seakeeping characteristics, as it is a relatively large, heavy ship with a low KG.

4.2.3.2 SWAN Analysis

The SWAN software package was used to calculate RAOs for the SOF ship. Analyses were conducted for three different ship speeds (12 kts, 18 kts, and 24 kts) and seven wave periods (6-18 sec). This provided enough permutations to accurately assess the ship's performance over most normal operating conditions. Appendix G shows the SWAN input files for the three different speeds, SWAN output files, and SWAN RAO files. The goal of the SWAN analysis was to obtain the RAO functions for the ship.

The RAO outputs from SWAN were then entered into the SWAN Integrator Excel spreadsheet. This spreadsheet calculated the Pierson-Moskowitz sea spectrum for a given wave height. A significant wave height of 3.1 meters, corresponding to sea state 5, was used in this analysis. The SWAN RAOs were also used to calculate actual ship motions (roll, pitch, heave, and heave velocity) at a location 75 ft fwd and aft of the midships on the flight deck. The spreadsheet produced plots of the sea spectrum, the RAOs, and the ship response spectrum. These plots are also shown in Appendix G for the three speeds specified.

The flight deck location was analyzed to determine the feasibility of flight operations at various speeds. The criteria to conduct flight operations were: pitch angle less than 3°, roll angle less than 5°, and heave velocity less than 6.5 ft/s with seas broad off the bow at 150 degrees. The results for the three speeds are summarized in Table 26.

Table 26: Flight Deck Motions for Various Speeds

	Limit	12 knots	18 knots	24 knots
Pitch (degrees)	3.0	0.05	0.04	0.03
Roll (degrees)	5.0	0.11	0.12	0.12
Heave velocity (ft/s)	6.5	0.219	0.208	0.164
Heave (m)	N/A	0.11	0.09	0.08

The flight deck motion analysis indicates that the SOF ship can conduct flight operations in sea state 5 up to its maximum sustained speed of 24 knots. Generally, as the ship's speed increases, it becomes more stable and motions decrease. As speed increases, the maximum value of the spectrum peak decreases. Therefore, as the design currently stands, flight operations would NOT be limited at any speed in Sea State 5.

4.2.4 Environmental

As the conversion did not affect existing waste processing equipment, the ship maintains the same level of environmental standards and remains in compliance with US Navy policy for waste disposal. There will, however, be a need for increased sanitation equipment due the addition of SOF. All sanitation equipment installed for this conversion will meet all guidelines and environmental standards within US Navy environmental policies.

4.3 Operation and Support

The SOF ship crew is the same as that of the LMSR. This crew will operate the ship under all circumstances. When a SOF group is embarked, the ship's crew and SOF will operate largely independent of each other. However, as mentioned previously, SOF will be required to provide personnel to augment the ship's crew with "hotel" tasks.

4.4 Cost and Risk

4.4.1 Cost Estimation

A weight-based methodology developed by the MIT 13A program was modified and used to estimate the conversion costs. The estimate is broken down into removal costs, addition costs, shipbuilder, and government costs. Table 27 lists the major cost estimates in FY03 dollars. The model assumed a 3% inflation rate, an in-service date of 2004, and a 30-year service life. The development of the SOF model sought to be cost-effective in all decisions. Each specific modification received a cost estimate through a SWBS breakdown approximation of weights added and removed. This weight change was entered into the weight-based cost model and a variant cost was obtained. Accuracy of this variant cost is subject to change based on contractor and overhead costs. This weight-based cost analysis produced costs within sponsor requirements. If the entire removal and addition of weights was performed in the cheapest category of the SWBS breakdown groups (Hull Structure), the estimated conversion cost is 41.2 million dollars. Obviously, there are electrical and outfitting modifications that need to be performed, and these SWBS weight groups have higher Cost Equivalent Ratios (CERs) associated with them. That brings the conversion cost to 86.16 million dollars. Further investigation would need to be performed in this area to

ensure that the CERs being used are accurate. The complete cost model is included in Appendix H.

Table 27. Conversion Cost Estimates

Estimate Source	Estimate ($M)
Conversion of LMSR to SOF Ship	86.16
New construction of LMSR	250.00
New construction of SOF Ship	300.49

The LMSR program currently has 19 ships. The addition of each ship to the fleet lowers the cost associated with each follow-on vessel. The values listed above take into account the lead ship serving as a follow-on ship. The cost calculated for new construction of an LMSR using our cost model is 434.29 million dollars. According to Avondale Industries, the contract for the seventh strategic sealift ship is $250 million. A cost correction factor of 0.576 was applied to the total SOF conversion cost and new construction ships.

4.4.2 Risk

Risk can be defined as the probability of failure multiplied by a measure of the consequences of failure. This design attempts to minimize risk where feasible, while still maintaining an aggressive approach to use of innovative technology to improve effectiveness and lower cost. The following areas were considered in the risk areas in the assessment of the SOF Ship design:

- Development of the flight deck
- Advanced berthing installation and messing
- Development of modularized C4I infrastructure

The primary function of the SOF Ship is to support SOF missions. A failure in this area is a failure of the mission of the ship. Therefore, the two most important areas to develop are the flight deck and hangar bay. Flight decks have been installed on carriers for over 80 years. However, as with all other new ship modifications, first time installation of a new component is always full of risk. The technology used to install the new flight deck, therefore must be compatible with that used to install the flight decks on the other modern CVNs or LHAs.

Advanced crew berthing and accommodation technology is well developed, and has been used successfully on recent ship modifications. These berthings are light, simple to construct, and provide more crew comfort. It is essential that such technology be incorporated into the design of this ship for weight reduction and reduced equipment costs.

The last area of possible risk entails the development of modularized C4I systems. Since SOF bring their own equipment, it was essential that sections of the ship be designated for such equipment as a "plug and play" design. Further study would have to be conducted in this area to determine exactly what modifications would have to be made to the existing command and control systems, particularly what kind of electronic provisions would have to be "cable ready".

5.0 DESIGN CONCLUSIONS

5.1 Summary of Final Concept Design

Starting from a T-AKR 300, the SOF ship development process created a platform with the same, or improved, weight, KG, and strength. Table 28 summarizes the SOF Ship conversion design.

Table 28. SOF Ship Dimensions and Performance

LBP	884 ft	**LOA**	951 ft
Beam	106 ft	**Full Load Draft**	27.80 ft
Full Load Displacement	48,937 ltons	**Light Ship Displacement**	37,681 ltons
Full Load KG	39.98 ft	**Light Ship KG**	45.67 ft
Max speed	24.0 knots	**Endurance**	10,000 + nm @ 24 knots

The SOF ship design removes the topside cranes, aft ramp, and internal deck hatches and ramps from the current LMSR. It was important to retain the original superstructure for cost reduction as well as for strength and stability concerns. The flight deck was then mounted on the main deck and the elevators were added. The SOF Ship design increases the lightship weight by 3957 long tons. The ship's crew size remains the same, but it has capacity for an additional 2000 personnel for troop transport. Also, a ship self-defense system was installed for protection against threats. Similarly, space was allocated for the command and communications center for mission need. The cost of the conversion is estimated at $86.16 million. Table 29 summarizes the removals and additions to the original ship.

Table 29. Summary of Removals and Additions

Removals	Additions
Cranes	Flight Deck
Aft Ramp	Elevators
Topside Fan Rooms	Ship Self-Defense System
Internal Hatches and Ramps	Command and Control Centers
	Ready/Briefing/SCIF Rooms
	Berthing Facilities
	Weapons Magazines
	Ship Support Storage
	Mission Support Storage
	Medical and Dental Facilities
	Boat Cranes and Winches
	AC/ventilation

5.2 Final Conclusions and Recommendations

Conversion of an LMSR, such as the T-AKR 300, to a SOF platform is feasible and merits consideration. The design meets the requirements for a cost-effective, near-term solution to the need for a SOF/Aviation support platform. The ship serves as a mobile offshore platform for SOF mission support and is equipped with its own self-defense armament.

Based on the MNS guidance and policy, the SOF platform will provide support for interagency, joint, and Allied forces. This vessel will provide modular flexibility to perform individual or multiple missions, thereby freeing other major assets to dedicate their full resources in the performance of their primary missions. As a result, this conversion provides a valuable asset to the fleet.

This report describes ship conversion concept design results based on SOF mission estimates. A hands-on inspection of the Bob Hope class LMSR would serve to improve the accuracy of space allocation and design for this project. Further analysis is required in the following areas:

- cost analysis and LMSR follow-on ship costs
- elevator cross section structural strength (using software program like Maestro)
- detailed manning breakdown for routine functions
- ventilation and air conditioning system
- hotel services such as sanitation services
- hangar bay drainage/freeboard issues
- boat launch and recovery details
- detailed wind study

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[14] Ships Drawing and Specifications, T-AKR 300 Bob Hope Class

[15] Weight and Moment Estimate, T-AKR 300 Bob Hope Class

The Program of Ships Salvage and Engineering (POSSE) and Ship Wave Analysis (SWAN) software packages were used for this for this study.

Appendix A
Mission Needs Statement

UNCLASSIFIED

MISSION NEED STATEMENT

FOR

A SPECIAL OPERATIONS FORCES SHIP

1. DEFENSE PLANNING GUIDANCE ELEMENT

a. This Mission Need Statement (MNS) provides requirements for a Special Operations Forces (SOF) ship for the near future. The multi-mission capabilities are a result of the chosen combat suite, hull, and mechanical and electrical systems. The above systems ensure battlespace dominance for expeditionary, interagency, joint and allied forces. This ship must operate wherever required to provide SOF capabilities. The mission capabilities must be fully interoperable with other naval, interagency, joint and allied forces.

b. This MNS should guide 21st Century SOF surface ship design, research, development and acquisition program decisions, service and joint doctrine, and cooperative efforts with U.S. allies.

2. MISSION AND THREAT ANALYSIS

a. Mission. The general mission of this ship is to provide integrated SOF capabilities, to provide independent forward presence, and to operate as an integral part of joint and allied maritime warfare operations.

b. Objectives. The Special Operations Forces Ship must have flexibility to meet the multi-mission requirements, while at the same time, employing a self defense capability against a variety of threats. It must be interoperable with other expeditionary, interagency, joint, and allied forces under the C4I for the Warrior/Copernicus architecture. The Special Operations Forces Ship must contribute to open ocean surface, air, and sub-surface dominance.

c. Capabilities.

(1) Power Projection – The ship must destroy or neutralize enemy targets ashore through the use of coordinated aviation and special operations forces.   It must be capable of conducting cooperative operations with other ships, submarines, aircraft, space and land systems.

(2) Battlespace Dominance – To support regional expeditionary, joint and allied force operations, and maintain sea lines of communication. The ship must be able to embark and support armed rotary-wing, VTOL/STOVL aircraft as well as deployment of SOF.

(3) Command, Control and Surveillance – The ship must be fully interoperable with other naval, interagency, joint, and allied forces, and with space and ground based sensors under the C4I for the Warrior/Copernicus architecture. The communications suite must have an integrated database capable of interfacing in a Joint Task Force/Combined Task Force (JTF/CTF) environment to include

compatibility with joint systems such as the Global Command and Control System (GCCS), the Joint Worldwide Intelligence Communications System (JWICS) and the Joint Deployable Intelligence Support System (JDISS). It must be designed to be a tactical operational extension using Tactical Command Center (TCC) and Tactical Data Information Exchange System (TADIX) within the emerging Joint Communications Planning and Management System. The ship must have a full suite of radios and antennas to support full connectivity via EHF/SHF/UHF SATCOM using full DAMA for each circuit. The ship must have an cryptologic capability designed to collect, process and geolocate signals of interest in order to describe and fully exploit the electronic battle space. Cryptologic capability is required to provide near real-time indications and warning and situational awareness to tactical decision makers and to support CO situational awareness, coordinate actions with other forces and communicate the ship's actions to appropriate commanders. Connectivity must include seamless integration for both organic and off-ship sensor inputs to shooter actions.

(4) Survivability – The ship shall have the survivability criteria of ship system redundancy to ensure graceful degradation of capability to make the total loss of the ship highly unlikely even if hit.

(5) Mobility – The ship must steam to design capability and maneuver at sustained task force speeds. The design must provide sufficient machinery redundancy for graceful degradation of mobility and survivability. The ship must be able to perform seamanship, airmanship and navigation tasks; prevent and control damage; and replenish at sea.

(6) Fleet Support Operations – Conduct in-flight refueling of rotary wing aircraft; conduct Search and Rescue (SAR) operations; and provide routine health care, first aid assistance, triage and resuscitation.

(7) Non-Combat Operations – The ship must provide emergency and disaster assistance; support operations to evacuate noncombatant personnel in areas of civil or international crisis; support and conduct vertical takeoff and/or rotary wing aircraft operations; provide unit-level upkeep and maintenance.

3. NON-MATERIAL ALTERNATIVES

Mission Area Analyses were conducted as part of the SOF/Aviation support platform. These analyses determined that changes in doctrine and operational concepts are not sufficient to address deficiencies. Doctrine changes and operational concepts required without a SOF platform would include: inability to project expeditionary strike power from the sea; severely degraded ability to project precise strike power against land targets; inability to maintain meaningful, visible forward presence for coalition building; thus requiring allies undertake these missions.

4. **POTENTIAL MATERIEL ALTERNATIVES**
   a. Material alternatives include (1) conversion of an amphibious class ship to a special operations forces ship, (2) conversion of a commercial tanker/container ship/roll-on roll-off vessel, (3) conversion of an existing LMSR ship, and (4) design and acquisition of a new ship.
   b. The ongoing LMSR acquisition program could potentially address this need through a forward-fit modification program by capitalizing on advanced technology. However, to do this, it would need to employ a modified approach in the design.

5. CONSTRAINTS

a. Key Boundary Conditions.

(1) Architecture – The ship design must employ a total ship architectural/engineering approach that optimizes life cycle cost and performance; minimizes operating conflicts; permits rapid upgrade and change in response to evolving operational requirements; allows computational and communication resources to keep technological pace with commercial capabilities wherever possible. More specifically this implies physical element modularity; functional sharing of hardware; open systems information architecture; ship wide resource management; automation of Command, Control, Communications, and Computers (C4I), combat engineering, and navigation functions; integrated ship wide data management; automation and minimization of maintenance and administrative functions; and embedded training. The approach should also promote commonality of design among ship classes.

(2) Design – Consideration should be given to the maximum use of modular designs in the SOF ship infrastructure. Emerging technologies must be accounted for during the developmental phase. Since communication and data systems hold the greatest potential for growth, and therefore obsolescence, their installations must be modularized as much as possible to allow for future upgrades. Use standard man-to-machine interfaces among the systems onboard. The man-to-machine interfaces should be consistent with existing user-friendly systems.

(3) Personnel – The ship must be automated to a sufficient degree to realize significant manpower reductions in engineering, combat systems, ship support and Condition III watchstanding requirements.

(4) Back-fit – Major functional elements of a Special Operations Forces Ship must be applicable to other forward fit ship construction programs.

b. Operational Constraints.

(1) The Special Operations Forces Ship must incur only minimal degradation of operational capability in heavy weather or in the presence of electromagnetic, nuclear, biological and chemical contamination and/or shock effects from nuclear and conventional weapon attack.

(2) Any Special Operations Forces Ship must meet the survivability requirements of Level I as defined in OPNAVINST 9070.1.

(3) The Special Operations Forces Ship must provide rotary-wing, VTOL/STOVL, and unmanned aerial vehicle (UAV) landing and hangaring facilities. Ammunition storage for operational support of armed aircraft must also be provided.

(4) The ship must be able to operate in U.S., foreign, and international waters in full compliance with existing U.S. and international pollution control laws and regulations.

(5) All ship and combat system elements must make use of standard subsystems and meet required development practices. The Special Operations Forces Ship must be fully integrated with other U.S. Navy, Marine Corps, joint and allied forces, and other agencies. Joint goals for standardization and interoperability will be achieved to the maximum feasible extent.

(6) The ship must be able to transit through the Panama Canal (PANAMAX).

Appendix B
Weights Removed/Added

13.413.-
Conversion
Project

#		Element	Weight Tons	VCG ft	Moment ft-tons	LCG ft	Moment ft-tons	TCG ft	Moment ft-tons
			Displacem	**KG light**		**LCG**		**TCG**	
	Light		**33723.00**	**48.07**	**1621173.00**	**496.87**	**16756014.00**	**0.32**	**10640.00**
1		123	9.81	125.00	1226.00	701.11	6876.49	-13.98	-137.12
2	Fan house 03	123	3.65	125.00	456.00	700.10	2553.96	-42.34	-154.46
3	fan enclosures A deck	123	15.24	93.00	1416.86	221.23	3370.44	5.38	81.96
4	04 mod to stack	162	57.35	142.93	8196.75		44338.61	11.66	668.68
5	HULL STRUCTURAL CLOSURES	167	162.10	93.33	15129	766.00	124169	0.00	0
6	Hatch, scuttle & berp	168	3.89	93.33	363.43	756.56	2946.04	-7.55	-29.40
	Deck A-B	168	2012.00	82.00	164984.00	687.00	1382244.00	0.00	0.00
7	Hinged ramp A dk to B dk	169	36.54	99.00	3616.97	723.74	26441.84	-13.08	-477.88
8	Hinged ramp B dk to C dk	169	132.35	66.00	8734.84	639.02	84571.74	35.52	4700.93
10	fan enclosures A deck	123	1.90	104.00	198.06	687.00	1308.31	99.00	188.53
11	Kingpost for sternramp	172	173.84	132.00	22947.14	910.16	158224.03	0.10	17.38
12	Cargo hatches inst. Arrays	172	10.71	99.69	1067.28	322.14	3448.83	-2.82	-30.19
	TOTAL GROUP	**170**	**2619.37**	**87.17**	**228336.11**	**702.65**	**1840492.89**	**1.84**	**4828.45**
	GROUP 100 WITH AB DK		**2619.37**	**87.17**	**228336.11**	**702.65**	**1840492.89**	**1.84**	**4828.45**
	GROOP 100		**607.37**	**87.17**	**228336.11**	**702.65**	**1840492.89**	**1.84**	**4828.45**
13	Mchry csg A-03	259	15.74	120.00	1888.44	759.76	11956.34	12.49	196.56
	TOTAL GROUP	**250**	**15.74**	**120.00**	**1888.44**	**759.76**	**11956.34**	**12.49**	**196.56**
	GROUP 200		**15.74**	**120.00**	**1888.44**	**759.76**	**11956.34**	**12.49**	**196.56**
14	Emerg dsl outf	312	29.61	120.00	3552.60	882.26	26119.31	-0.33	-9.77
15	Blw arr 05 dk	313	0.11	143.00	15.30	757.00	81.00	-23.00	-2.46
	TOTAL GROUP	**310**	**29.71**	**120.08**	**3567.90**	**881.81**	**26200.31**	**-0.41**	**-12.23**
16	Outft Emerg diesel	342	2.40	120.00	250.18	885.57	2128.02	3.66	8.79
	TOTAL GROUP	**340**	**2.40**	**104.11**	**250.18**	**885.57**	**2128.02**	**3.66**	**8.79**

Weight Removed

17	Outft Emerg diesel	398	2.08	120.00	212.65	885.10	1836.58	1.94	4.03
	TOTAL GROUP	**390**	**2.08**	**102.49**	**212.65**	**885.10**	**1836.37**	**1.94**	**4.02**
	GROUP 300		**34.19**	**117.89**	**4030.73**	**882.27**	**30164.70**	**0.02**	**0.58**
18	Outft Emerg diesel	512	2.49	120.00	298.92	885.57	2205.95	-4.55	-11.33
	TOTAL GROUP	**510**	**2.49**	**120.00**	**298.92**	**885.57**	**2205.95**	**-4.55**	**-11.33**
19	Outft Emerg diesel	526	0.14	120.00	17.28	885.98	127.58	1.09	0.16
20	Mchnery csge to 03 lvl	526	0.20	120.00	23.40	765.38	149.25	5.55	1.08
	TOTAL GROUP	**520**	**0.34**	**120.00**	**40.68**	**816.61**	**276.83**	**3.66**	**1.24**
21	Mchnery csge to 03 lvl	534	0.42	120.00	45.20	766.33	323.39	5.10	2.15
	TOTAL GROUP	**530**	**0.42**	**107.11**	**45.20**	**766.33**	**323.39**	**5.10**	**2.15**
22	Mchnery csge to 03 lvl	551	0.34	120.00	36.91	766.96	261.53	5.96	2.03
	TOTAL GROUP	**550**	**0.34**	**108.24**	**36.91**	**766.96**	**261.53**	**5.96**	**2.03**
23	Stern ramp assembly inst.	589	20.53	132.00	2709.56	912.05	18721.65	0.00	0.00
24	Stern ramp	589	242.15	132.00	31963.14	950.94	230265.37	0.00	0.00
25	Twin crane & boom rest	589	405.74	117.29	47588.66	612.08	248342.28	-4.45	-1805.52
	TOTAL GROUP	**580**	**668.41**	**123.07**	**82261.36**	**744.05**	**497329.30**	**-2.70**	**-1805.52**
26	Twin crane & boom rest	598	23.63	120.65	2850.47	441.50	10430.44	0.00	0.00
	TOTAL GROUP	**590**	**23.63**	**120.65**	**2850.47**	**441.50**	**10430.44**	**0.00**	**0.00**
	GROUP 500		**695.63**	**122.96**	**85533.54**	**734.34**	**510827.44**	**-2.60**	**-1811.43**
27	Misc. boards & signs	631	0.59	123.91	73.35	776.56	459.72	1.31	0.78
28	Deck covering schedule	634	98.50	127.50	12558.75	766.00	75451.00	0.00	0.00
	TOTAL GROUP	**630**	**99.09**	**127.48**	**12632.10**	**766.06**	**75910.72**	**0.01**	**0.78**
	GROUP 600		**99.09**	**127.48**	**12632.10**	**766.06**	**75910.72**	**0.01**	**0.78**
	MODIFICATION INCLUDED AB DK (for POSSE analysis)		**3464.01**	**95.96**	**332420.92**	**712.86**	**2469352.10**	**0.93**	**3214.93**
	TOTAL MODIFICATION		**1452.01**	**95.96**	**332420.92**	**712.86**	**2469352.10**	**0.93**	**3214.93**

		Total Disp	VCG		LCG	TCG
FINAL STABILITY PARAMETERS		30258.99	42.59		472.14	0.25

		Weight Added							
			Displacem	**KG after mod**		**LCG**		**TCG**	
		Light	**30258.99**	**42.59**	**0.00**	**472.14**	**0.00**	**0.25 tons**	**10640.00**
#	**Description**	**Element**	**Weight**	**VCG**	**Moment**	**LCG**	**Moment**	**TCG**	**Moment**
			Tons	**ft**	**ft-tons**	**ft**	**ft-tons**	**ft**	**ft-tons**
1	Flying deck fwd section	111	1210.49	89.37	108181.76	102.02	123494.50	0.00	0.00
2	Flying deck ctr section	111	1449.19	89.37	129514.29	351.63	509579.38	0.00	0.00
3	Flying deck aft section	111	175.35	89.37	15670.94	740.06	129768.78	0.00	0.00
4	Fly. Dk Longit. Framing	116	55.19	83.00	4580.52	475.00	26213.83	0.00	0.00
5	Fly. Dk Trans. Framing	117	192.00	83.00	15936.00	475.00	91200.00	0.00	0.00
6	Fan house 02	123	3.23	18.00	58.07	181.35	585.04	-2.78	-8.97
7	Fan house 03	123	3.46	18.00	62.28	727.00	2515.42	-1.16	-4.01
	TOTAL GROUP	**170**	**3088.91**	**88.71**	**274003.86**	**285.98**	**883356.94**	**0.00**	**-12.98**
8	Mchry csg A-03	185	0.70	18.00	12.60	183.90	128.73	-0.56	-0.39
9	04dk frame fnd	184	0.29	130.02	37.58	780.08	225.44	41.27	11.93
10	04dk fnd	185	1.36	109.78	149.30	706.01	960.17	23.60	32.10
11	04dk fnd	185	0.10	109.78	11.09	793.41	80.13	45.51	4.60
12	04dk fnd	185	0.85	110.00	93.83	776.98	662.76	-11.09	-9.46
13	04dk fnd	185	0.07	110.78	8.20	774.00	57.28	46.42	3.44
14	04dk fnd	185	0.07	110.00	8.14	798.00	59.05	-46.42	-3.44
15	04dk fnd	185	0.04	109.78	3.95	675.17	24.31	52.29	1.88
16	04dk fnd	185	0.02	110.00	1.76	766.68	12.27	2.29	0.04
17	04dk fnd	185	2.07	110.34	228.29	697.00	1442.09	-19.94	-41.26
18	04dk fnd	185	0.04	110.11	4.84	784.17	34.50	-52.36	-2.30
19	Comp array blw 04 dk	185	2.72	124.98	339.95	732.36	1992.02	-0.92	-2.50
20	Comp array blw 04 dk	185	3.26	125.21	408.69	781.42	2550.55	-7.19	-23.47
21	Comp array blw 04 dk	185	0.37	125.00	46.63	828.89	309.18	3.64	1.36
22	Comp array blw 04 dk	185	1.90	125.21	237.40	739.04	1401.22	-3.45	-6.54
23	Comp array blw 04 dk	185	1.14	125.00	142.75	733.71	837.90	-0.10	-0.11
24	Comp array blw 04 dk	185	1.48	124.98	185.47	780.78	1158.68	-0.71	-1.05
141	Arrg H dk	185	0.13	90.00	11.70	871.74	113.33	35.25	4.58

142	Arrg H dk	185	3.46	90.00	311.58	756.70	2619.70	1.04	3.60
143	Arrg H dk	185	0.43	90.00	38.79	781.94	337.02	10.21	4.40
144	Arrg H dk	185	0.46	90.00	41.58	780.91	360.78	-17.02	-7.86
145	Arrg H dk	185	1.44	90.00	129.60	799.02	1150.59	-35.25	-50.76
32	Comp array blw 04 dk	185	0.18	121.98	21.83	775.73	138.86	-6.61	-1.18
33	Comp array blw 04 dk	185	0.16	122.00	19.64	839.88	135.22	2.40	0.39
34	Comp array blw 04 dk	185	0.23	121.98	28.06	744.60	171.26	2.97	0.68
35	Comp array blw 04 dk	185	0.09	122.12	11.48	802.46	75.43	3.35	0.31
144	Comp array blw 04 dk	185	0.20	122.14	24.18	799.85	158.37	0.04	0.01
145	Comp array blw 04 dk	185	0.25	122.23	31.05	855.94	217.41	0.00	0.00
146	Comp array blw 04 dk	185	0.35	121.78	42.62	744.96	260.74	-3.83	-1.34
147	Comp array blw 04 dk	185	0.72	122.00	87.84	799.52	575.65	4.69	3.38
148	Comp array blw 04 dk	185	0.22	121.98	26.59	741.04	161.55	1.34	0.29
149	Comp array blw 04 dk	185	0.16	122.12	19.66	760.30	122.41	-7.78	-1.25
150	Comp array blw 04 dk	185	0.18	122.14	22.23	826.90	150.50	0.50	0.09
44	Comp array blw 04 dk	185	0.41	122.23	49.75	846.75	344.63	-2.45	-1.00
45	Comp array blw 04 dk	185	0.31	122.00	37.70	728.07	224.97	-0.15	-0.05
46	Comp array blw 04 dk	185	0.20	122.00	23.79	793.46	154.72	-11.20	-2.18
47	Comp array H dk	185	0.14	91.00	12.47	829.87	113.69	-2.88	-0.39
48	Comp array H dk	185	0.23	91.00	20.84	883.17	202.25	-22.13	-5.07
49	Comp array H dk	185	0.32	91.00	28.67	844.95	266.16	-3.47	-1.09
50	Side shell 04	185	0.81	120.00	97.68	649.05	528.33	6.12	4.98
51	Side shell 04	185	0.15	120.00	17.40	585.44	84.89	51.54	7.47
52	HELO ELEV. Supp. Sys. PORT	185	145.60	60.00	8736.00	550.05	80087.28	35.50	5168.80
53	HELO ELEV. Supp. Sys. STDB	185	145.60	60.00	8736.00	390.05	56791.28	-35.50	-5168.80
54	Arrg H dk	185	0.33	91.00	30.03	846.29	279.28	-10.11	-3.34
55	Arrg H dk	185	1.57	91.00	143.14	887.07	1395.36	-10.77	-16.94
56	Arrg H dk	185	1.08	91.00	98.55	845.78	915.98	-5.60	-6.06
57	Int arrgment	185	0.17	90.00	14.85	799.00	131.84	-10.44	-1.72
58	Hdk frame fnd	185	0.14	90.00	12.87	801.00	114.54	15.56	2.23
59	Hdk frame fnd	185	0.13	90.00	11.61	786.00	101.39	1.92	0.25
60	Hdk fnd	185	0.07	90.00	6.39	794.00	56.37	43.25	3.07
61	Hdk fnd	185	0.07	90.00	6.57	702.00	51.25	-19.34	-1.41
62	Hdk fnd	185	0.14	90.00	12.24	767.00	104.31	40.38	5.49
63	Hdk fnd	185	0.21	90.00	18.81	819.63	171.30	-28.47	-5.95
64	Hdk fnd	185	4.13	90.00	371.61	817.89	3377.07	0.10	0.41
65	Emergency diesel mach. Foundations	185	160.00	16.10	2576.00	220.78	35324.80	0.00	0.00
66	Storerooms + issue rooms	185	814.11	15.00	12211.65	201.00	163636.11	6.45	5251.01

	TOTAL GROUP	**180**	**1301.07**	**27.72**	**36063.51**	**279.11**	**363142.88**	**3.96**	**5149.84**
	GROUP 100		**4389.98**	**70.63**	**310067.36**	**283.94**	**1246499.82**	**1.17**	**5136.86**
67	Mchry csg A-03	259	15.74	16.00	251.79	219.76	3458.36	12.49	196.56
	GROUP 200		**15.74**	**16.00**	**251.79**	**219.76**	**3458.36**	**12.49**	**196.56**
68	Emerg dsl outf	312	29.61	18.00	532.98	183.90	5445.28	-0.56	-16.58
	TOTAL GROUP	**310**	**29.61**	**18.00**	**532.98**	**183.90**	**5445.28**	**-0.56**	**-16.58**
69	Mchnery csge to 03 lvl	321	2.02	18.00	36.34	183.90	371.29	-0.56	-1.13
70	Outft Emerg diesel	324	1.05	18.00	18.90	183.90	193.14	-0.56	-0.59
71	Comp array blw 04 dk	321	0.44	120.00	53.28	788.91	350.28	-0.74	-0.33
72	Pwr sys lvl 04	321	0.47	124.90	58.45	793.50	371.36	0.00	0.00
73	Comp array blw 04 dk	324	0.11	120.00	12.84	772.00	82.60	-0.75	-0.08
74	Arrg below H dk	321	0.87	91.00	79.17	832.55	724.32	1.23	1.07
75	Arrg below H dk	321	1.26	91.00	115.02	854.09	1079.57	-1.81	-2.29
76	Arrg below H dk	321	0.59	91.00	53.60	877.25	516.70	0.00	0.00
77	Pwr sys H dk	321	0.47	60.00	28.08	893.50	418.16	0.00	0.00
78	**TOTAL GROUP**	**320**	**7.28**	**62.60**	**455.69**	**564.26**	**4107.42**	**-0.46**	**-3.35**
79	Mchnery csge to 03 lvl	331	0.03	18.00	0.61	183.90	6.21	-0.56	-0.02
80	Light sys dk 04	331	0.10	98.99	9.70	734.50	71.98	0.00	0.00
81	Comp array blw 04 dk	332	0.77	98.99	75.83	795.73	609.53	-4.17	-3.19
82	Arrg below 04 dk	332	0.81	98.78	79.91	743.72	601.67	0.00	0.00
83	Arrg below 04 dk	332	0.88	99.12	87.23	770.38	677.93	-8.79	-7.74
84	Arrg below 04 dk	332	1.01	99.12	99.71	841.00	846.05	0.00	0.00
85	Arrg below H dk	332	0.29	99.14	28.35	832.94	238.22	0.57	0.16
86	Arrg below H dk	332	0.26	99.00	25.64	888.14	230.03	1.14	0.30
87	Arrg below H dk	332	0.86	98.99	85.33	861.50	742.61	0.00	0.00
88	Comp & fltr house	331	0.15	18.00	2.61	744.50	107.95	12.50	1.81
89	Comp & fltr house	331	0.15	18.00	2.61	744.50	107.95	12.50	1.81
0	**TOTAL GROUP**	**330**	**5.29**	**94.06**	**497.53**	**801.58**	**4240.13**	**-1.30**	**-6.87**
90	Outft Emerg diesel	342	12.40	18.00	223.20	183.90	2280.36	-0.56	-6.94
91	Mchnery csge from 03 lvl	342	10.16	18.00	182.88	183.90	1868.42	-0.56	-5.69
92	Arrg H dk	342	3.08	77.00	237.08	872.86	2687.78	12.42	38.24
	TOTAL GROUP	**340**	**25.64**	**25.09**	**643.16**	**266.65**	**6836.56**	**1.00**	**25.61**
93	Outft Emerg diesel	398	2.08	18.00	37.44	183.90	382.51	1.94	4.04
	TOTAL GROUP	**390**	**2.08**	**18.00**	**37.44**	**183.90**	**382.51**	**1.94**	**4.04**
	GROUP 300		**69.90**	**31.00**	**2166.81**	**300.61**	**21011.91**	**0.04**	**2.85**
94	Antenna arrgment	421	0.10	47.70	4.77	727.25	72.73	0.00	0.00

95	Antenna arrgment	422	1.36	47.70	64.92	730.00	993.53	-5.07	-6.90
96	Elec. arrgment	421	0.10	39.70	3.97	727.25	72.73	0.00	0.00
97	Elec. arrgment	422	1.36	39.70	54.03	730.00	993.53	-5.07	-6.90
	TOTAL GROUP	**420**	**2.92**	**43.70**	**127.69**	**729.81**	**2132.51**	**-4.72**	**-13.80**
98	Comp array blw 04 dk	432	0.46	120.00	55.68	745.00	345.68	-4.00	-1.86
99	General Alarm sys	436	1.88	120.00	225.60	776.00	1458.88	0.00	0.00
100	Fire & smoke det sys	436	2.02	120.00	242.64	776.00	1569.07	0.00	0.00
101	Antenna arrgment	434	0.26	47.70	12.45	732.00	191.05	9.87	2.58
102	Comp array C Dk	432	0.46	47.70	22.13	745.00	345.68	-4.00	-1.86
103	Gral Alarm sys	436	1.88	47.70	89.68	776.00	1458.88	0.00	0.00
104	Fire & smoke det sys	436	2.02	47.70	96.45	776.00	1569.07	0.00	0.00
105	Elec. arrgment	434	0.26	39.70	10.36	732.00	191.05	9.87	2.58
106	Comp array C Dk	432	0.46	39.70	18.42	735.00	341.04	-4.00	-1.86
107	Gral Alarm sys	436	1.88	39.70	74.64	735.00	1381.80	0.00	0.00
108	Fire & smoke det sys	436	2.02	39.70	80.27	735.00	1486.17	0.00	0.00
109	Comp array C Dk	432	0.46	47.30	21.95	387.00	179.57	-4.00	-1.86
110	Gral Alarm sys	436	1.88	47.40	89.11	384.00	721.92	0.00	0.00
111	Fire & smoke det sys	436	0.20	47.20	9.44	386.00	77.20	0.00	0.00
112	Comp array blw B dk	432	0.76	39.70	30.33	369.00	281.92	-4.00	-3.06
113	Boat crane STBD	432	17.00	61.3	1042.10	369.00	6273.00	42.00	714.00
114	Boat crane PORT	432	17.00	61.3	1042.10	369.00	6273.00	-42.00	-714.00
	TOTAL GROUP	**430**	**50.93**	**62.11**	**3163.35**	**474.10**	**24144.98**	**-0.10**	**-5.33**
115	Radio room	441	1.83	47.70	87.34	738.55	1352.29	1.97	3.61
116	Antenna arrgment	441	0.75	47.70	35.78	729.07	546.80	-5.22	-3.92
117	Radar Equipment	445	0.20	47.70	9.54	743.36	148.67	0.00	0.00
118	Satellite coms	446	0.74	47.70	35.30	744.76	551.12	0.00	0.00
119	Radio room	441	1.83	39.70	72.69	748.55	1370.60	1.97	3.61
120	Elec. arrgment	441	0.75	39.70	29.78	739.07	554.30	-5.22	-3.92
121	Satellite coms	445	0.20	39.70	7.94	743.36	148.67	0.00	0.00
122	Satellite coms	446	0.74	39.70	29.38	744.76	551.12	0.00	0.00
	TOTAL GROUP	**440**	**7.04**	**43.70**	**307.74**	**741.77**	**5223.57**	**-0.09**	**-0.62**
123	Shipboard PC cabling	493	0.80	124.00	99.20	792.50	634.00	0.00	0.00
124	Cmd & surv	499	1.80	127.87	230.17	760.00	1368.00	0.00	0.00
125	Shipboard PC cabling	493	0.80	47.70	38.16	792.50	634.00	0.00	0.00
126	Cmd & surv	499	1.80	47.70	85.86	760.00	1368.00	0.00	0.00
127	Shipboard PC cabling	493	0.80	39.70	31.76	735.00	588.00	0.00	0.00
128	Cmd & surv	499	1.80	39.70	71.46	735.00	1323.00	0.00	0.00

#	Description	Code							
129	Shipboard PC cabling	493	2.00	47.70	95.40	385.00	770.00	0.00	0.00
130	METEOROLOGICAL SYSTEM	494	0.70	123.00	86	798.00	558.60	0.00	0
131	SPECIAL PURPOSE INTELLIGENCE	495	1.20	119.00	143	810.00	972.00	0.00	0
132	SPECIAL PURPOSE INTELLIGENCE	495	1.80	121.50	219	803.00	1445.40	-12.80	-23
133	Cmd & surv	499	1.80	46.80	84.24	382.00	687.60	0.00	0.00
134	**TOTAL GROUP**	**490**	**15.30**	**77.38**	**1183.85**	**676.38**	**10348.60**	**-1.51**	**-23.04**
	GROUP 400		**76.19**	**62.77**	**4782.62**	**549.27**	**41849.67**	**-0.56**	**-42.78**
135	Mchnery csge to E DK	511	0.18	18.00	3.24	183.84	33.09	-0.76	-0.14
136	Outft Emerg diesel	512	2.49	18.00	44.82	182.90	455.42	1.56	3.88
137	Mchnery csge to E Dk	512	2.04	18.00	36.72	183.67	374.69	-0.56	-1.14
138	Mchnery csge to E DK	514	0.33	18.00	5.94	189.90	62.67	-0.56	-0.18
139	Mchnery csge to E DK	514	0.33	18.00	5.85	766.76	249.20	4.15	1.35
140	AIR CONDITIONING SYSTEM	514	94.94	25.00	4568.00	628.17	59638.00	14.23	1351
	TOTAL GROUP	**510**	**100.47**	**46.46**	**4667.45**	**606.32**	**60914.10**	**13.45**	**1351.69**
141	Outft Emerg diesel	526	0.14	18.00		183.84	25.74	-0.76	-0.11
142	Mchnery csge E DK	526	0.20	18.00	3.60	189.90	37.98	-0.56	-0.11
143	WASHDOWN SYSTEM	523	8.54	25.00	213.50	456.61	3899.43	-14.56	-124.3424
144	PLUMBING DRAINAGE AFT	528	28.03	25.78	723	657.90	18440.94	5.78	162
145	PLUMBING DRAINAGE FWD	528	32.00	15.00	480	134.89	4316.48	0.00	0
146	DRAINAGE AND BALLASTING SYSTEM	529	353.41	19.00	6715	346.89	122594	1.90	671
	TOTAL GROUP	**520**	**422.32**	**19.27**	**8137.02**	**353.56**	**149314.96**	**1.68**	**708.93**
147	Miscellaneous tanks	532	0.32	19.73	6.31	686.00	219.52	32.00	10.24
148	Mchnery csge to E DK	534	0.42	18.00	7.56	183.90	77.24	1.94	0.81
150	Piping Diesel Emer. Mach Box	534	3.04	38.69	117.62	675.50	2053.51	-22.02	-66.94
	TOTAL GROUP	**530**	**3.78**	**34.79**	**131.49**	**621.76**	**2350.27**	**-14.78**	**-55.89**
151	Helo FUEL & FUEL COMPENSATING	541	19.24	30.00	577.20	534.88	10291.00	-7.95	-152.97164
152	Helo FUEL & FUEL Purif. Sys	541	35.00	15.00	525.00	134.96	4723.60	0.00	0
	TOTAL GROUP	**540**	**54.24**	**20.32**	**1102.20**	**276.82**	**15014.60**	**-2.82**	**-152.97**
153	Comp array blw E Dk	551	0.08	18.00	1.39	803.11	61.84	2.67	0.21
154	Fire exstinguishing system	555	72.00	15.00	1080.00	535.77	38575.44	0.00	0.00
	TOTAL GROUP	**550**	**72.08**	**15.00**	**1081.39**	**536.06**	**38637.28**	**0.00**	**0.21**
155	REPLENISHMENT AT SEA SYSTEMS	571	20.00	78.30	1566	345.64	6913	0.00	0
	TOTAL GROUP	**570**	**20.00**	**78.30**	**1566.00**	**345.64**	**6912.80**	**0.00**	**0.00**
156	Aircraft Recov. Supp. Sys.	586	196.20	78.00	15303.60	352.50	69160.50	-15.95	-3129.39
157	Aircraft Launch. Supp. Sys.	587	291.60	78.00	22744.80	326.25	95134.50	25.50	7435.80
158	Aircraft Handling, serv, stowage	588	100.00	76.00	7600.00	452.50	45250.00	0.00	0.00

159	Liferafts	583	9.42	94.50	890.28	166.45	1568.13	26.80	252.48
160	Liferafts	583	9.42	94.00	885.57	166.45	1568.13	-26.80	-252.48
161	Environmental Polution Control Sys	583	46.20	15.00	693.00	135.88	6277.66	0.00	0.00
162	HELO Handling, serv, stowage	588	100.00	71.00	7100.00	352.50	35250.00	3.56	356.00
	TOTAL GROUP	**580**	**752.84**	**73.35**	**55217.26**	**337.67**	**254208.91**	**6.19**	**4662.41**
	GROUP 500		**1425.72**	**49.33**	**70336.81**	**369.88**	**527352.92**	**4.57**	**6514.38**
163	Non structural balckheads	621	205.23	15.00	3078.45	135.78	27866.13	0.00	0.00
164	Ladders	623	0.57	45.00	25.70	737.24	420.96	6.88	3.93
165	Interior joiner stairs	623	2.54	45.00	114.30	740.49	1880.84	11.85	30.10
166	Loiner door & wind list	624	19.67	45.00	885.24	738.12	14520.30	-13.20	-259.67
167	Ladders	623	4.56	45.00	205.20	737.24	3361.81	6.88	31.37
168	Interior joiner stairs	623	2.54	35.00	88.90	740.49	1880.84	11.85	30.10
169	Auxiliary System fundation FWD	623	158.63	15.00	2379.45	220.00	34898.60	6.79	1077.10
170	Loiner door & wind list	624	19.67	35.00	688.52	738.12	14520.30	1.75	34.43
	TOTAL GROUP	**620**	**413.42**	**18.06**	**7465.76**	**240.31**	**99349.79**	**2.29**	**947.35**
171	refrig. Stores arr & dets	638	18.51	18.00	333.23	581.00	10756.05	0.00	0.00
	TOTAL GROUP	**630**	**18.51**	**18.00**	**333.23**	**581.00**	**10756.05**	**0.00**	**0.00**
172	Officer Berthing+messing	641	11.40	59.70	680.58	531.00	6053.40	0.00	0.00
173	Toilett & shower arrgment	644	15.78	59.70	942.07	485.48	7660.87	0.79	12.47
174	NON-COMM OFFICER BERTH & MESS	642	6.45	34.98	225.621	403.78	2604.381	0	0.00
175	ENLISTED PERSONNEL BERTH & MESS	643	19.12	34.97	668.6264	405.98	7762.3376	0	5.74
176	SANITARY SPACES & FIXTURES	644	19.67	35.03	689.0401	408.76	8040.3092	0	0.00
177	LEISURE & COMMUNITY SPACES	645	3.12	34.89	108.8568	409.33	1277.1096	0	0.00
178	NON-COMM OFFICER BERTH & MESS	642	6.45	34.98	225.621	602.34	3885.093	0	0.00
179	ENLISTED PERSONNEL BERTH & MESS	643	19.12	34.97	668.6264	609.45	11652.684	0	5.74
180	SANITARY SPACES & FIXTURES	644	19.67	35.03	689.0401	604.67	11893.8589	0	0.00
181	LEISURE & COMMUNITY SPACES	645	3.12	35.00	109.2	605.89	1890.3768	0	0.00
182	NON-COMM OFFICER BERTH & MESS	642	6.45	34.98	225.621	602.34	3885.093	0	0.00
183	ENLISTED PERSONNEL BERTH & MESS	643	19.12	34.97	668.6264	609.45	11652.684	0	5.74
184	SANITARY SPACES & FIXTURES	644	19.67	35.03	689.0401	604.67	11893.8589	0	0.00
185	LEISURE & COMMUNITY SPACES	645	3.12	35.00	109.2	605.89	1890.3768	0	0.00
186	NON-COMM OFFICER BERTH & MESS	642	6.45	34.98	225.621	602.34	3885.093	0	0.00
187	ENLISTED PERSONNEL BERTH & MESS	643	19.12	34.97	668.6264	609.45	11652.684	0	5.74
188	SANITARY SPACES & FIXTURES	644	19.67	35.03	689.0401	604.67	11893.8589	0	0.00

#	Description							
189	LEISURE & COMMUNITY SPACES	645	3.12	35.00	109.2	605.89	1890.3768	0	0.00
190	NON-COMM OFFICER BERTH & MESS	642	6.45	34.98	225.621	403.78	2604.381	0	0.00
191	ENLISTED PERSONNEL BERTH & MESS	643	19.12	34.97	668.6264	405.98	7762.3376	0	5.74
192	SANITARY SPACES & FIXTURES	644	19.67	35.03	689.0401	408.76	8040.3092	0	0.00
193	LEISURE & COMMUNITY SPACES	645	3.12	35.00	109.2	409.33	1277.1096	0	0.00
194	NON-COMM OFFICER BERTH & MESS	642	6.45	34.98	225.621	403.78	2604.381	0	0.00
195	MESS	643	19.12	34.97	668.6264	405.98	7762.3376	0	
196	SPACES & FIXTURES	644	19.67	35.03	689.0401		8040.3092	0	0.00
197	LEISURE & COMMUNITY SPACES	645	3.12	35.00	109.2	409.33	1277.1096	0	0.00
	TOTAL GROUP	**640**	**317.34**	**37.11**	**11777.23**	**506.50**	**160732.72**	**0.15**	**46.88**
198	MEDICAL EQ	652	18.90	47.70	901.53	382.00	7219.80	0.00	0.00
199	Galley & scullery	651	25.93	36.13	936.81	567.00	14701.74	33.51	868.88
200	Joiner	652	1.54	36.01	55.46	576.89	888.41	-7.80	-12.01
201	Joiner 02-01 dks	654	0.31	35.98	11.26	587.90	184.01	24.46	7.66
202	Laundries	655	13.47	35.97	484.55	586.45	7900.07	-28.42	-382.85
203	trash & trash compactor	656	7.40	36.09	266.99	845.60	6255.75	27.14	200.78
204	COMMISSARY PROVISIONS	651	16.56	20.00	331.20	576.90	9553.46	2.11	34.94
	TOTAL GROUP	**650**	**84.11**	**35.52**	**2987.81**	**555.26**	**46703.25**	**8.53**	**717.40**
205	Offices	661	12.90	65.04	839.02	631.00	8139.90	0.00	0.00
206	Briefing rooms	661	12.90	65.13	840.18	631.00	8139.90	0.00	0.00
207	Decontam. Sta.	664	20.09	64.78	1301.62	431.00	8660.08	0.00	0.00
208	Workshops. Labs, test areas	665	50.00	64.67	3233.50	631.00	31550.00	0.00	0.00
209	Decontam. Sta.	664	1.09	65.34	71.42	794.50	74.13	12.07	13.19
210	OFFICES	661	6.87	65.14	447.51	679.33	4667	2.77	19.0
211	MACHINERY CTL CENTER FURNISHINGS	662	2.09	35.00	73.15	728.23	1522	6.70	14.0
212	ELEC. CONTROL CENTER FURNISHINGS	663	2.09	35.00	272	657.42	1374	9.09	19.0
213	DAMAGE CONTROL STATION	664	31.25	65.00	2031.25	107.55	3361	33.44	1045.0
214	WORKSHOPS,LAB,TEST AREA	665	13.21	65.00	858.65	691.22	9131	7.80	103.0
	TOTAL GROUP	**660**		**65.37**	**9968.30**	**502.43**	**76619.01**	**7.96**	**1213.19**
215	Shore pwr cable	671	0.70	83.00	58.10	431.00	301.70	0.00	0.00
216	Stwg life saving eqpmt	671	3.02	83.00	250.33	431.00	1299.90	0.00	0.00
217	Battery stowage	671	5.82	83.00	483.31	431.00	2509.71	2.67	15.55
218	Lockers arr. & details	671	4.73	50.00	236.70	431.00	2040.35	0.00	0.00
219	Cargo securing fitting cov.	671	16.09	43.87	705.82	331.00	5325.46	0.00	0.00
220	Battery stowage	671	0.82	47.70	39.26	382.00	314.39	12.51	10.30

221	Auxiliary Equipment space	673	153.80	15.00	2307.00	131.71	20257.00	1.89	290.68
222	Store room and issue room	673	165.00	14.99	2473.35	335.69	55388.85	8.67	1430.55
223	Cargo securing fitting draw.	673	5.09	47.70	242.75	231.20	1176.58	0.00	0.00
	TOTAL GROUP	**670**	**355.07**	**19.14**	**6796.61**	**249.56**	**88613.93**	**4.92**	**1747.08**
224	Repair parts and special tools	699	65.00	14.76	959.40	135.78	8825.70	0.00	0.00
	TOTAL GROUP	**690**	**65.00**	**14.76**	**959.40**	**135.78**	**8825.70**	**0.00**	**0.00**
	GROUP 600		**1405.95**	**28.66**	**40288.33**	**349.66**	**491600.46**	**3.32**	**4671.90**
225	PHALANX STDB	721	6.29	153.78	967.28	774.00	4868.46	-42.10	-264.81
226	PHALANX PORT	721	6.29	153.78	967.28	771.00	4849.59	42.10	264.81
227	RAM Launching Device STDB	721	0.94	145.00	136.01	771.00	723.20	-28.60	-26.83
228	RAM Launching Device PORT	721	0.94	145.00	136.01	774.00	726.01	28.60	26.83
229	MISSILE STOWAGE STDB (42)	723	2.94	13.00	38.22	607.5	1786.05	0.00	0.00
230	MISSILE STOWAGE PORT (42)	723	2.94	13.00	38.22	607.5	1786.05	0.00	0.00
	TOTAL GROUP	**720**	**20.34**	**112.26**	**2283.01**	**724.79**	**14739.36**	**0.00**	**0.00**
231	Lockers arr. & details	763	12.86	44.12	567.56	631.00	8117.18	28.45	365.98
232	Lockers arr. & details	763	4.86	77.00	374.53	756.85	654.14	22.89	111.34
	TOTAL GROUP	**760**	**17.73**	**53.14**	**942.09**	**494.77**	**8771.32**	**26.92**	**477.32**
	GROUP 700		**38.06**	**84.73**	**3225.10**	**617.66**	**23510.68**	**12.54**	**477.32**
	TOTAL MODIFICATION		**7421.54**	**58.09**	**431118.83**	**317.36**	**2355283.82**	**2.28**	**16957.08**

		Total Disp	VCG		LCG		TCG	
	FINAL STABILITY PARAMETERS	37680.53	45.64061423		441.6572402		0.651093	

Appendix C
Space Allocations

SSCS	Mission Support Area GROUP	Area		
		Required	Area Allocated	Difference
1	MISSION SUPPORT	170476.7083	170476.7083	0
1.1	COMMAND,COMMUNICATION+SURV	23178.79637	23178.79637	0
1.11	EXTERIOR COMMUNICATIONS	1466.77315	1466.77315	0
1.12	SURVEILLANCE SYS	5481.00758	5481.00758	0
1.13		12958.04112	12958.04112	0
1.131	COMBAT INFO CENTER	10000	10000	0
1.132	CONNING STATIONS	2958.04112	2958.04112	0
1.14	COUNTERMEASURES	758.173	758.173	0
1.15	INTERIOR COMMUNICATIONS	2393.49384	2393.49384	0
1.16	ENVIORNMENTAL CNTL SUP SYS	121.30768	121.30768	0
1.2	WEAPONS	5788.94246	5788.94246	0
1.3	AVIATION	141062.2306	141062.2306	0
1.311	LAUNCHING+RECOVERY AREAS	85000	85000	0
1.3123	HELICOPTER RECOVERY	40000	40000	0
1.32	AVIATION CONTROL	2000	2000	0
1.34002	HELICOPTER HANGAR AFT	2000	2000	0
1.35	AVIATION ADMINISTRATION	2000	2000	0
1.36	AVIATION MAINTENANCE	10000	10000	0
1.37	AIRCRAFT ORDINANCE	2062.23056	2062.23056	0
1.9	SM ARMS,PYRO+SALU BAT	446.73886	446.73886	0
1.91	SM ARMS (LOCKER)	374.42082	374.42082	0
1.94	ARMORY	72.31804	72.31804	0
2	HUMAN SUPPORT	103495.6943	103495.6943	0
2.1	LIVING	75000	75000	0
2.11	OFFICER LIVING	5500	5500	0
2.13	CREW LIVING	40000	40000	0
2.14	GENERAL SANITARY FACILITIES	145.8025	145.8025	0
2.14003	DECK WASHRM&WC	145.8025	145.8025	0
2.15	SHIP RECREATION FAC	2689	2689	0
2.16	TRAINING	1200	1200	0
2.2	COMMISSARY	21295.21	21295.21	0
2.22202	WARD ROOM GALLEY	1112	1112	0
2.22204	CREW GALLEY	10000	10000	0
2.22403	CREW SCULLERY	583.21	583.21	0
2.231	CHILL PROVISIONS	2400	2400	0
2.232	FROZEN PROVISIONS	3600	3600	0
2.233	DRY PROVISIONS	6000	6000	0
2.3	MEDICAL+DENTAL (MEDICAL)	1200	1200	0
2.4	GENERAL SERVICES	4350	4350	0
2.41	SHIP STORE FACILITIES	2000	2000	0
2.42001	LAUNDRY	650	650	0
2.44	BARBER SERVICE	450	450	0
2.46	POSTAL SERVICE	450	450	0
2.47	BRIG	1000	1000	0
2.48	RELIGIOUS	450	450	0
2.5	PERSONNEL STORES	76.98372	76.98372	0

2.6	CBR PROTECTION	1456.85858	1456.85858	0
2.7	LIFESAVING EQUIPMENT	116.642	116.642	0
3	SHIP SUPPORT	40006.68643	40006.68643	0
3.1	SHIP CNTL SYS(STEERING&DIVING)	3723.79585	3723.79585	0
3.2	DAMAGE CONTROL	7139.07361	7139.07361	0
3.3	SHIP ADMINISTRATION	4360.30802	4360.30802	0
3.301	GENERAL SHIP	493.97887	493.97887	0
3.302	EXECUTIVE DEPT	1133.17703	1133.17703	0
3.304	SUPPLY DEPT	1817.86557	1817.86557	0
3.305	DECK DEPT	300.35315	300.35315	0
3.306	OPERATIONS DEPT	314.9334	314.9334	0
3.307	WEAPONS DEPT	300	300	0
3.5	DECK AUXILIARIES	4357.74512	4357.74512	0
3.6	SHIP MAINTENANCE	20425.76383	20425.76383	0
3.62	OPERATIONS DEPT (ELECT SHOP)	653.1952	653.1952	0
3.63	WEAPONS DEPT (ORDINANCE SHOP)	332.4297	332.4297	0
3.64	DECK DEPT (CARPENTER SHOP)	659.61051	659.61051	0
3.71	SUPPLY DEPT	13760.25674	13760.25674	0
3.73	OPERATIONS DEPT	428.07614	428.07614	0
3.74	DECK DEPT (BOATSWAIN STORES)	3796.6971	3796.6971	0
3.75	WEAPONS DEPT	273.52549	273.52549	0
3.76	EXEC DEPT(MASTER-AT-ARMS STOR)	317.26624	317.26624	0
3.78	CLEANING GEAR STOWAGE	204.70671	204.70671	0
3.8	ACCESS (INTERIOR-NORMAL)	10060.95571	10060.95571	0
3.9	TANKS	797.24807	797.24807	0
4	SHIP MACHINERY SYSTEM	52166.96808	52166.96808	0
4.1	PROPULSION SYSTEM	13545.63546	13545.63546	0
4.3	AUX MACHINERY	11549.30763	11549.30763	0
4.31	GENERAL (AUX MACH DELTA)	6679.50413	6679.50413	0
4.32	A/C&REFRIGERATION	4869.8035	4869.8035	0
4.321	A/C(INCLUDE VENT)	3586.15829	3586.15829	0
4.322	REFRIGERATION	999.62194	999.62194	0
4.341	SEWAGE	189.54325	189.54325	0
4.342	TRASH	94.48002	94.48002	0
4.35	MECHANICAL SYSTEMS	703.93447	703.93447	0
4.36		15000	15000	0
	SUM	366146.0571	366146.0571	0

Appendix D
Tank Weights

TANK WEIGHT SUMMARY
FAIRED LINES PLAN

Fuel Oil Tanks

TANK NAME	WEIGHT LTons	% Full	CAPACITY LTons	VOLUME Bbls	NET VOL. Bbls	API GRAV.	TEMP. oF	SP.VOL. Bbls/LT	KG ft-BL	LCG ft-FP	TCG ft-CL	F.S. ft-LTons
W3D 8-80-2	272	98.0	278	1,893	1,893	----	60.0	6.9465	6.82	545.63A	41.58P	157
W3D 8-80-1	274	98.0	279	1,900	1,900	----	60.0	6.9465	6.75	545.37A	41.47S	149
W3B 8-68-1	274	98.0	280	1,903	1,903	----	60.0	6.9465	6.71	444.04A	41.30S	149
W3B 8-68-2	232	98.0	237	1,613	1,613	----	60.0	6.9465	6.04	443.87A	41.05P	53
W3C 8-74-1	279	98.0	284	1,936	1,936	----	60.0	6.9465	6.67	494.78A	41.41S	149
W3C 8-74-4	237	98.0	242	1,647	1,647	----	60.0	6.9465	6.01	494.37A	41.18P	53
TOTALS	1,568	98.0	1,600	10,891	10,891				6.52	495.98A	2.28S	710

Diesel Oil Tanks

TANK NAME	WEIGHT LTons	% Full	CAPACITY LTons	VOLUME Bbls	NET VOL. Bbls	API GRAV.	TEMP. oF	SP.VOL. Bbls/LT	KG ft-BL	LCG ft-FP	TCG ft-CL	F.S. ft-LTons
DP 8-32-1	662	98.0	675	4,596	4,596	----	60.0	6.9465	9.43	169.71A	10.13S	1,725
DP 8-32-2	635	98.0	648	4,412	4,412	----	60.0	6.9465	9.46	168.92A	10.31P	1,640
W3A 8-62-1	0	0.0	263	0	0	----	60.0	6.9465	7.60	393.80A	40.84S	0
W3A 8-62-4	195	98.0	199	1,356	1,356	----	60.0	6.9465	6.57	393.87A	40.48P	80
W4 8-86-3	447	98.0	456	3,106	3,106	----	60.0	6.9465	6.49	615.11A	40.52S	236
W4 8-86-6	452	98.0	461	3,141	3,141	----	60.0	6.9465	6.45	615.71A	40.40P	236
DB4A 8-98-01	166	98.0	170	1,155	1,155	----	60.0	6.9465	4.37	694.03A	21.75S	626
B4A 8-98-2	150	98.0	153	1,043	1,043	----	60.0	6.9465	4.50	693.16A	23.70P	355
DP 6-116-1	168	98.0	172	1,169	1,169	----	60.0	6.9465	30.16	837.48A	30.61S	557
ST 5-116-3	409	98.0	418	2,843	2,843	----	60.0	6.9465	46.75	847.28A	24.42S	411
ST 5-116-1	369	98.0	376	2,560	2,560	----	60.0	6.9465	46.75	851.50A	11.00S	188
SV 5-116-0	750	98.0	765	5,209	5,209	----	60.0	6.9465	46.75	852.05A	7.56P	1,265
DP 6-116-4	168	98.0	172	1,169	1,169	----	60.0	6.9465	30.16	837.48A	30.61P	557
TOTALS	4,572	92.8	4,928	31,760	31,760				22.38	579.79A	0.12S	7,876

Lube Oil Tanks

TANK NAME	WEIGHT LTons	% Full	CAPACITY LTons	VOLUME ft3	SP.VOL. ft3/LT	KG ft-BL	LCG ft-FP	TCG ft-CL	F.S. ft-LTons
RGS 5-116-11	71	98.0	72	2,988	42.2134	46.74	838.34A	48.94S	23
SSDG 5-116-9	13	98.0	13	531	42.2134	46.71	831.00A	45.50S	1
RGSL 5-116-7	50	98.0	51	2,129	42.2134	47.65	836.69A	41.00S	10
TOTALS	134	98.0	136	5,648		47.08	837.03A	45.62S	34

TANK WEIGHT SUMMARY
FAIRED LINES PLAN

Fresh Water Tanks

TANK NAME	WEIGHT LTons	% Full	CAPACITY LTons	VOLUME ft3	SP.VOL. ft3/LT	KG ft-BL	LCG ft-FP	TCG ft-CL	F.S. ft-LTons
POT 5-116-6	88	67.0	132	3,164	35.8814	48.21	838.50A	30.50P	42
POT 5-116-8	88	67.0	132	3,164	35.8814	48.21	838.50A	39.50P	42
DIS 5-116-10	57	67.0	85	2,054	35.8814	48.26	838.47A	49.92P	12
DTA 6-116-0	194	67.0	290	6,801	35.0062	27.91	838.00A	0.23S	2,056
APF 6-126-1	248	67.0	371	8,696	35.0062	33.90	862.98A	20.78S	7,980
APF 6-126-2	248	67.0	371	8,696	35.0062	33.90	862.98A	20.78P	7,980
TOTALS	925	67.0	1,381	32,575		36.26	851.55A	9.72P	18,114

SW Ballast Tanks

TANK NAME	WEIGHT LTons	% Full	CAPACITY LTons	VOLUME ft3	SP.VOL. ft3/LT	KG ft-BL	LCG ft-FP	TCG ft-CL	F.S. ft-LTons
FPK 6--12-0	0	0.0	733	0	35.0062	43.53	10.76A	0.00	0
NO1 8-25-0	0	0.0	1,090	0	35.0062	17.75	86.42A	0.00	0
W2A 8-44-01	0	0.0	310	0	35.0062	10.49	234.93A	20.92S	0
W2A 8-44-4	0	0.0	309	0	35.0062	10.49	235.65A	21.02P	0
W2B 8-50-1	0	0.0	244	0	35.0062	10.43	290.31A	32.99S	0
W2B 8-50-2	0	0.0	232	0	35.0062	10.22	290.93A	32.96P	0
W2C 8-56-1	0	0.0	224	0	35.0062	10.18	340.87A	39.63S	0
2C 8-56-2	132	60.0	219	4,605	35.0062	10.17	340.45A	39.68P	588
DB3F 8-62-0	0	0.0	412	0	35.0062	2.75	415.07A	11.46S	0
DB3F 8-62-2	342	98.0	349	11,980	35.0062	2.75	414.55A	13.52P	798
DB4F 8-86-0	0	0.0	415	0	35.0062	2.76	621.99A	11.49S	0
DB4F 8-86-2	345	98.0	352	12,085	35.0062	2.76	621.99A	13.54P	802
LC 7-94-1	0	0.0	341	0	35.0062	11.72	687.09A	38.73S	0
LC 7-94-2	334	98.0	341	11,695	35.0062	11.72	687.12A	38.74P	1,046
DB3A 8-74-2	332	98.0	338	12,931	39.0015	2.75	520.00A	14.00P	744
DB3A 8-74-0	257	65.0	395	10,006	39.0015	2.75	520.00A	12.00S	4,803
TOTALS	1,741	28.3	6,304	63,301		5.03	538.00A	16.67P	8,780

Misc. Tanks

TANK NAME	WEIGHT LTons	% Full	CAPACITY LTons	VOLUME ft3	SP.VOL. ft3/LT	KG ft-BL	LCG ft-FP	TCG ft-CL	F.S. ft-LTons
LOSM 8-104-1	53	98.0	54	1,911	35.8814	10.48	738.89A	17.81S	78
LOSM 8-105-2	38	98.0	39	1,374	35.8814	10.71	742.30A	17.74P	58
LORG 4-106-2	13	98.0	14	484	35.8814	52.33	746.50A	10.00P	7
LORG 4-106-4	10	98.0	10	363	35.8814	52.33	746.50A	17.00P	4
OWHT 8-98-0	21	98.0	21	743	35.8814	2.81	677.49A	5.92S	29
WOT 8-98-02	49	98.0	50	1,765	35.8814	2.90	683.62A	2.49P	151
LODT 8-103-4	50	98.0	51	1,796	35.8814	9.27	723.62A	18.21P	35
ERWO 8-104-0	79	98.0	80	2,827	35.8814	8.05	732.90A	0.00	102
GTWD 8-107-0	18	98.0	18	643	35.8814	9.58	756.79A	0.23P	25
OPS 7-112-2	11	98.0	12	411	35.8814	16.04	797.48A	7.76P	8
PST 7-112-1	11	98.0	11	399	35.8814	16.02	797.54A	7.56S	8

TANK WEIGHT SUMMARY
FAIRED LINES PLAN

Misc. Tanks

TANK NAME	WEIGHT LTons	% Full	CAPACITY LTons	VOLUME ft3	SP.VOL. ft3/LT	KG ft-BL	LCG ft-FP	TCG ft-CL	F.S. ft-LTons
GWT 5-126-1	63	98.0	64	2,252	35.8814	45.76	854.50A	39.40S	139
SWHT 5-130-1	39	98.0	40	1,408	35.8814	46.63	866.57A	37.83S	29
TOTALS	456	98.0	464	16,376		19.15	758.59A	6.57S	674

CARGO SUMMARY

Misc. Weights

ITEM	WEIGHT LTons	KG ft-BL	LCG ft-FP	TCG ft-CL	F.S. ft-LTons	FWD BND ft-FP	AFT BND ft-FP
CREW	360	35.00	544.50A	0.00	0	528.10A	560.90A
MISS EXPENS	120	32.00	522.50A	0.00	0	506.10A	538.90A
HELLO	127	80.00	472.00A	0.00	0	455.60A	488.40A
BOATS	117	80.00	472.00A	0.00	0	455.60A	488.40A
SHIPS STORES	678	28.00	475.00A	0.00	0	458.60A	491.40A
MEDICAL	19	47.40	365.50A	0.00	0	349.10A	381.90A
DRY STORES	260	28.00	510.00A	0.00	0	493.60A	526.40A
FREEZE STORE	180	28.00	509.30A	0.00	0	492.90A	525.70A
TOTALS	1,861	36.63	498.20A	0.00	0		

TANK WEIGHT SUMMARY
FAIRED LINES PLAN

Fuel Oil Tanks

TANK NAME	WEIGHT LTons	% Full	CAPACITY LTons	VOLUME Bbls	NET VOL. Bbls	API GRAV.	TEMP. oF	SP.VOL. Bbls/LT	KG ft-BL	LCG ft-FP	TCG ft-CL	F.S. ft-LTons
W3D 8-80-2	186	67.0	278	1,294	1,294	----	60.0	6.9465	6.82	545.63A	41.58P	1,482
W3D 8-80-1	187	67.0	279	1,299	1,299	----	60.0	6.9465	6.75	545.37A	41.47S	1,482
W3B 8-68-1	187	67.0	280	1,301	1,301	----	60.0	6.9465	6.71	444.04A	41.30S	1,432
W3B 8-68-2	159	67.0	237	1,103	1,103	----	60.0	6.9465	6.04	443.87A	41.05P	1,432
W3C 8-74-1	191	67.0	284	1,324	1,324	----	60.0	6.9465	6.67	494.78A	41.41S	1,485
W3C 8-74-4	162	67.0	242	1,126	1,126	----	60.0	6.9465	6.01	494.37A	41.18P	1,485
TOTALS	1,072	67.0	1,600	7,446	7,446				6.52	495.98A	2.28S	8,799

Diesel Oil Tanks

TANK NAME	WEIGHT LTons	% Full	CAPACITY LTons	VOLUME Bbls	NET VOL. Bbls	API GRAV.	TEMP. oF	SP.VOL. Bbls/LT	KG ft-BL	LCG ft-FP	TCG ft-CL	F.S. ft-LTons
DP 8-32-1	452	67.0	675	3,142	3,142	----	60.0	6.9465	9.43	169.71A	10.13S	4,038
DP 8-32-2	434	67.0	648	3,017	3,017	----	60.0	6.9465	9.46	168.92A	10.31P	3,914
W3A 8-62-1	0	0.0	263	0	0	----	60.0	6.9465	7.60	393.80A	40.84S	0
W3A 8-62-4	133	67.0	199	927	927	----	60.0	6.9465	6.57	393.87A	40.48P	997
W4 8-86-3	306	67.0	456	2,124	2,124	----	60.0	6.9465	6.49	615.11A	40.52S	2,428
W4 8-86-6	309	67.0	461	2,147	2,147	----	60.0	6.9465	6.45	615.71A	40.40P	2,501
DB4A 8-98-01	114	67.0	170	790	790	----	60.0	6.9465	4.37	694.03A	21.75S	6,065
B4A 8-98-2	103	67.0	153	713	713	----	60.0	6.9465	4.50	693.16A	23.70P	4,508
DP 6-116-1	115	67.0	172	799	799	----	60.0	6.9465	30.16	837.48A	30.61S	2,239
ST 5-116-3	280	67.0	418	1,944	1,944	----	60.0	6.9465	46.75	847.28A	24.42S	429
ST 5-116-1	252	67.0	376	1,750	1,750	----	60.0	6.9465	46.75	851.50A	11.00S	189
SV 5-116-0	513	67.0	765	3,561	3,561	----	60.0	6.9465	46.75	852.05A	7.56P	1,702
DP 6-116-4	115	67.0	172	799	799	----	60.0	6.9465	30.16	837.48A	30.61P	2,239
TOTALS	3,126	63.4	4,928	21,714	21,714				22.38	579.79A	0.12S	31,249

Lube Oil Tanks

TANK NAME	WEIGHT LTons	% Full	CAPACITY LTons	VOLUME ft3	SP.VOL. ft3/LT	KG ft-BL	LCG ft-FP	TCG ft-CL	F.S. ft-LTons
RGS 5-116-11	48	67.0	72	2,043	42.2134	46.74	838.34A	48.94S	23
SSDG 5-116-9	9	67.0	13	363	42.2134	46.71	831.00A	45.50S	1
RGSL 5-116-7	34	67.0	51	1,455	42.2134	47.65	836.69A	41.00S	53
TOTALS	91	67.0	136	3,861		47.08	837.03A	45.62S	77

TANK WEIGHT SUMMARY
FAIRED LINES PLAN

Fresh Water Tanks

TANK NAME	WEIGHT LTons	% Full	CAPACITY LTons	VOLUME ft3	SP.VOL. ft3/LT	KG ft-BL	LCG ft-FP	TCG ft-CL	F.S. ft-LTons
POT 5-116-6	43	33.0	132	1,558	35.8814	48.21	838.50A	30.50P	42
POT 5-116-8	43	33.0	132	1,558	35.8814	48.21	838.50A	39.50P	42
DIS 5-116-10	28	33.0	85	1,012	35.8814	48.26	838.47A	49.92P	12
DTA 6-116-0	96	33.0	290	3,350	35.0062	27.91	838.00A	0.23S	2,056
APF 6-126-1	122	33.0	371	4,283	35.0062	33.90	862.98A	20.78S	7,980
APF 6-126-2	122	33.0	371	4,283	35.0062	33.90	862.98A	20.78P	7,980
TOTALS	455	33.0	1,381	16,044		36.26	851.55A	9.72P	18,114

SW Ballast Tanks

TANK NAME	WEIGHT LTons	% Full	CAPACITY LTons	VOLUME ft3	SP.VOL. ft3/LT	KG ft-BL	LCG ft-FP	TCG ft-CL	F.S. ft-LTons
FPK 6--12-0	0	0.0	733	0	35.0062	43.53	10.76A	0.00	0
NO1 8-25-0	0	0.0	1,090	0	35.0062	17.75	86.42A	0.00	0
W2A 8-44-01	0	0.0	310	0	35.0062	10.49	234.93A	20.92S	0
W2A 8-44-4	0	0.0	309	0	35.0062	10.49	235.65A	21.02P	0
W2B 8-50-1	0	0.0	244	0	35.0062	10.43	290.31A	32.99S	0
W2B 8-50-2	228	98.0	232	7,968	35.0062	10.22	290.93A	32.96P	399
W2C 8-56-1	0	0.0	224	0	35.0062	10.18	340.87A	39.63S	0
2C 8-56-2	136	62.0	219	4,758	35.0062	10.17	340.45A	39.68P	588
DB3F 8-62-0	0	0.0	412	0	35.0062	2.75	415.07A	11.46S	0
DB3F 8-62-2	342	98.0	349	11,980	35.0062	2.75	414.55A	13.52P	798
DB4F 8-86-0	249	60.0	415	8,718	35.0062	2.76	621.99A	11.49S	4,949
DB4F 8-86-2	345	98.0	352	12,085	35.0062	2.76	621.99A	13.54P	802
LC 7-94-1	334	98.0	341	11,708	35.0062	11.72	687.09A	38.73S	1,033
LC 7-94-2	334	98.0	341	11,695	35.0062	11.72	687.12A	38.74P	1,046
DB3A 8-74-2	332	98.0	338	12,931	39.0015	2.75	520.00A	14.00P	744
DB3A 8-74-0	387	98.0	395	15,086	39.0015	2.75	520.00A	12.00S	1,033
TOTALS	2,687	43.3	6,304	96,929		5.99	542.22A	7.19P	11,392

Misc. Tanks

TANK NAME	WEIGHT LTons	% Full	CAPACITY LTons	VOLUME ft3	SP.VOL. ft3/LT	KG ft-BL	LCG ft-FP	TCG ft-CL	F.S. ft-LTons
LOSM 8-104-1	36	66.0	54	1,287	35.8814	10.48	738.89A	17.81S	261
LOSM 8-105-2	26	66.0	39	925	35.8814	10.71	742.30A	17.74P	212
LORG 4-106-2	9	66.0	14	326	35.8814	52.33	746.50A	10.00P	11
LORG 4-106-4	7	66.0	10	244	35.8814	52.33	746.50A	17.00P	5
OWHT 8-98-0	14	66.0	21	500	35.8814	2.81	677.49A	5.92S	86
WOT 8-98-02	33	66.0	50	1,189	35.8814	2.90	683.62A	2.49P	595
LODT 8-103-4	34	66.0	51	1,209	35.8814	9.27	723.62A	18.21P	94
ERWO 8-104-0	53	66.0	80	1,904	35.8814	8.05	732.90A	0.00	194
GTWD 8-107-0	12	66.0	18	433	35.8814	9.58	756.79A	0.23P	61
OPS 7-112-2	8	66.0	12	277	35.8814	16.04	797.48A	7.76P	33
PST 7-112-1	7	66.0	11	268	35.8814	16.02	797.54A	7.56S	29

TANK WEIGHT SUMMARY
FAIRED LINES PLAN

misc. Tanks

TANK NAME	WEIGHT LTons	% Full	CAPACITY LTons	VOLUME ft3	SP.VOL. ft3/LT	KG ft-BL	LCG ft-FP	TCG ft-CL	F.S. ft-LTons
GWT 5-126-1	42	66.0	64	1,517	35.8814	45.76	854.50A	39.40S	317
SWHT 5-130-1	26	66.0	40	948	35.8814	46.63	866.57A	37.83S	40
TOTALS	307	66.0	464	11,029		19.15	758.59A	6.57S	1,937

CARGO SUMMARY

Misc. Weights

ITEM	WEIGHT LTons	KG ft-BL	LCG ft-FP	TCG ft-CL	F.S. ft-LTons	FWD BND ft-FP	AFT BND ft-FP
CREW	360	35.00	544.50A	0.00	0	528.10A	560.90A
MISS EXPENS	40	32.00	522.50A	0.00	0	506.10A	538.90A
HELO	127	80.00	472.00A	0.00	0	455.60A	488.40A
BOATS	117	80.00	472.00A	0.00	0	455.60A	488.40A
SHIP'S STORE	224	28.00	475.00A	0.00	0	458.60A	491.40A
MEDICAL	19	47.40	465.40A	0.00	0	449.00A	481.80A
DRY STORES	86	28.00	510.00A	0.00	0	493.60A	526.40A
FREEZE STORE	59	28.00	509.30A	0.00	0	492.90A	525.70A
TOTALS	1,032	43.25	505.08A	0.00	0		

Appendix E
POSSE Intact Stability Analysis

STILL WATER FULL LOAD

TRIM & STABILITY SUMMARY
FAIRED LINES PLAN

ITEM	WEIGHT LTons	KG ft-BL	LCG ft-FP	TCG ft-CL	FSmom ft-LTons
Light Ship	37,681	45.57	441.70A	0.65S	
Constant	0	0.00	452.50A	0.00	0
RoRo Cargo	0	0.00	452.50A	0.00	
Misc. Weight	1,861	36.63	437.82A	0.00	0
Fuel Oil	546	6.78	545.50A	0.02S	306
Diesel Oil	5,404	19.97	547.16A	0.65P	8,265
Lube Oil	134	47.08	837.03A	45.62S	34
Fresh Water	230	48.22	838.49A	38.66P	97
SW Ballast	2,625	12.68	645.23A	7.86P	7,737
Misc.	456	19.15	758.59A	6.57S	674
TOTALS	48,937	39.98	471.18A	0.01S	17,112

STABILITY CALCULATION

KMt	52.27	ft
KG	39.98	ft
GMt	12.29	ft
FSc	0.35	ft
GMt Corrected	11.94	ft
GMt Required	5.25	ft
GMt Margin	6.69	ft

TRIM CALCULATION

LCF Draft	27.82	ft
LCB (even keel)	470.69	ft-AFT
LCF	482.80	ft-AFT
MT1in	9,776	ft-LT/in
Trim	0.20	ft-AFT
Prop. Immersion	114	%
List	0.06	deg-STBD

DRAFTS

F.P. 27ft- 8.5in (8.45m)   Fwd Marks 27ft- 8.6in (8.45m)
M.S. 27ft- 9.7in (8.48m)   M.S.Marks 27ft- 9.8in (8.48m)
A.P. 27ft-11.0in (8.51m)   Aft Marks 27ft-10.9in (8.51m)

STRENGTH CALCULATIONS

Shear Force at 110   4,585 LT
Bending Moment at 76   1,107,598 ft-LTons [HOG]

SHEAR & LONGITUDINAL BENDING STRESS SUMMARY
Stresses in ksi
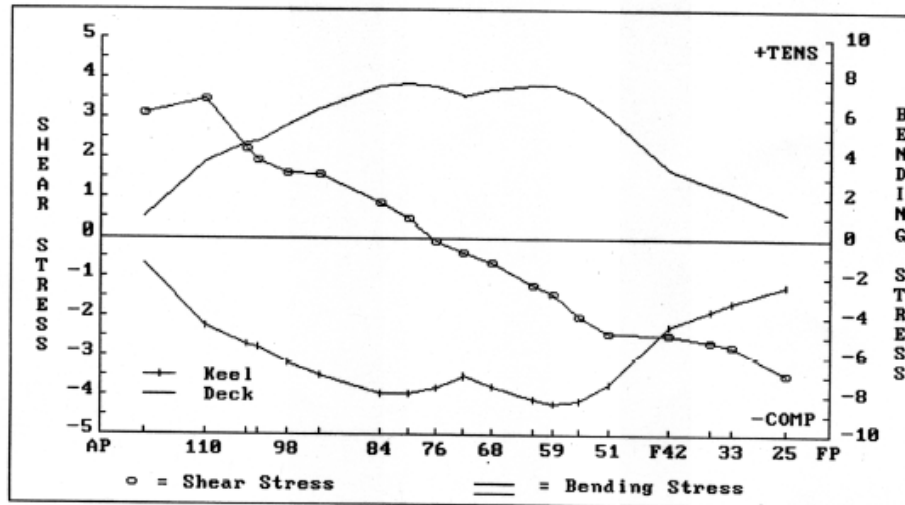
FAIRED LINES PLAN

No.	LOCATION ft-FP	SHEAR FORCES SHEAR LTons	SHEAR STRESS ksi	BENDING MOMENTS MOMENT ft-LTons	DK STRESS ksi	KL STRESS ksi
25	55.00A	-1,429	-3.47	49,265H	1.18	-2.39
33	121.00A	-2,644	-2.73	185,367H	2.22	-3.27
36	148.00A	-3,161	-2.65	264,029H	2.63	-3.70
F42	199.00A	-3,998	-2.46	447,575H	3.37	-4.51
51	274.00A	-3,529	-2.41	743,701H	6.08	-7.39
55	310.00A	-2,827	-1.99	859,240H	7.15	-8.27
59	343.00A	-2,071	-1.43	940,011H	7.65	-8.46
62	367.00A	-1,807	-1.19	985,371H	7.63	-8.19
68	418.00A	-1,043	-0.61	1,064,676H	7.39	-7.53
MS	452.50A	-657	-0.36	1,089,776H	7.07	-7.00
72	454.00A	-656	-0.36	1,090,745H	7.10	-7.03
76	487.00A	-140	-0.08	1,107,598H	7.56	-7.61
80	520.00A	736	0.43	1,097,524H	7.72	-7.92
84	556.00A	1,411	0.84	1,058,446H	7.55	-7.91
93	631.00A	2,660	1.57	885,618H	6.39	-7.01
98	673.00A	2,765	1.61	776,889H	5.60	-6.31
F98	709.00A	3,348	1.93	667,409H	4.80	-5.54
104	724.00A	3,642	2.21	615,177H	4.67	-5.42
110	775.00A	4,585	3.46	404,154H	3.76	-4.50
126	851.00A	2,619	3.08	70,660H	1.00	-1.30

Maximum Shear Stress at 25:   -3.47 ksi
Maximum Deck Bending Stress at 80:   7.72 ksi
Maximum Keel Bending Stress at 59:   -8.46 ksi

STILL WATER FULL LOAD
WIND

TRIM & STABILITY SUMMARY
FAIRED LINES PLAN

ITEM	WEIGHT LTons	KG ft-BL	LCG ft-FP	TCG ft-CL	FSmom ft-LTons
Light Ship	37,681	45.57	441.70A	0.65S	
Constant	0	0.00	452.50A	0.00	0
RoRo Cargo	0	0.00	452.50A	0.00	
Misc. Weight	1,861	36.63	437.82A	0.00	0
Fuel Oil	546	6.78	545.50A	0.02S	306
Diesel Oil	5,404	19.97	547.16A	0.65P	8,265
Lube Oil	134	47.08	837.03A	45.62S	34
Fresh Water	230	48.22	838.49A	38.66P	97
SW Ballast	2,625	12.68	645.23A	7.86P	7,737
Misc.	456	19.15	758.59A	6.57S	674
TOTALS	48,937	39.98	471.18A	0.01S	17,112

STABILITY CALCULATION

KMt	52.27	ft
KG	39.98	ft
GMt	12.29	ft
FSc	0.35	ft
GMt Corrected	11.94	ft
GMt Required	5.25	ft
GMt Margin	6.69	ft

TRIM CALCULATION

LCF Draft	27.82	ft
LCB (even keel)	470.69	ft-AFT
LCF	482.80	ft-AFT
MT1in	9,776	ft-LT/in
Trim	0.20	ft-AFT
Prop. Immersion	114	%
List	0.06	deg-STBD

DRAFTS

F.P. 27ft- 8.5in (8.45m)   Fwd Marks 27ft- 8.6in (8.45m)
M.S. 27ft- 9.7in (8.48m)   M.S.Marks 27ft- 9.8in (8.48m)
A.P. 27ft-11.0in (8.51m)   Aft Marks 27ft-10.9in (8.51m)

STRENGTH CALCULATIONS

Shear Force at 110   4,585 LT
Bending Moment at 76   1,107,598 ft-LTons [HOG]

BEAM WIND with ROLLING STABILITY EVALUATION
(per U.S. Navy DDS079-1)

FAIRED LINES PLAN

	Available	Required
Wind Heeling Arm Lw	0.18 ft	
Maximum Righting Arm	8.00 ft	0.30 ft
Capsizing Area A2	67.3 ft-deg	
Righting Area A1	295.1 ft-deg	94.2 ft-deg

Wind Velocity	=	100 knots	Mean Draft =	27.81 ft
Wind Pressure Factor=		0.0035	Displacement =	48,937 LTons
Wind Pressure	=	0.0156 LT/ft2	GMt (corrected) =	11.94 ft
Projected Sail Area =		19409.7 ft2	Roll Angle =	25.0 deg
Vertical Arm	=	43.09 ft ABL		
Heeling Arm at 0 deg=		0.18 ft	Angle at Intercept=	60.0 deg
Wind Heel Arm Lw	=	0.18 ft	Maximum GZ =	8.00 ft
Wind Heel Angle	=	0.9 deg	Angle at Max. GZ =	38.4 deg

STILL WATER FULL LOAD
TURN

EFFECT on STABILITY of HIGH SPEED TURNING
(per U.S. Navy DDS079-1)

FAIRED LINES PLAN
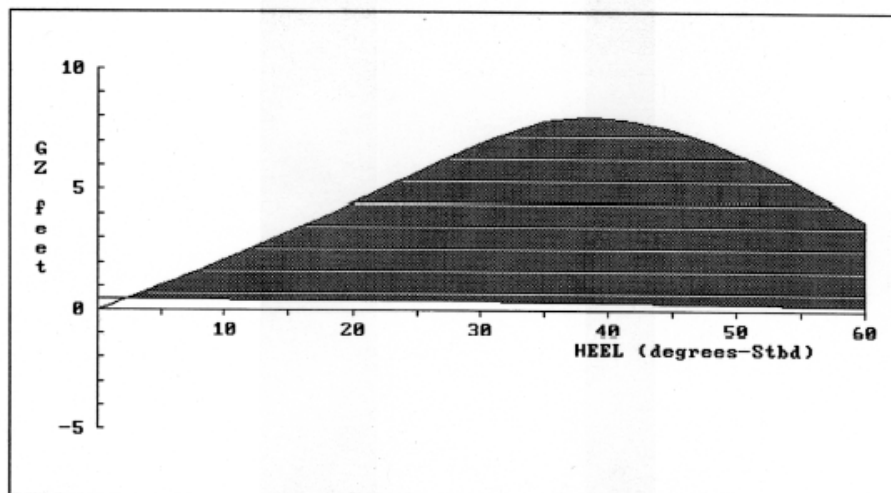
	Available	Required
Angle of Heel	2.2 deg	15.0 deg
Heeling Arm Lc	0.44 ft	
Maximum Righting Arm	8.00 ft	0.74 ft
Total Righting Area	302.6 ft-deg	
Reserve Righting Area	281.1 ft-deg	121.0 ft-deg

Ship Speed in Turn	=	24.0 knots	Displacement	= 48,937 LTons
Turn Circle Radius	=	3000 ft	VCG	= 39.98 ft
Heeling Arm at 0 deg=		0.44 ft	Mean Draft	= 27.81 ft
Angle at Max. GZ	=	38.4 deg	Positive GZ Range =	60.0 deg
			Angle at Intercept=	60.0 deg

INTACT STABILITY FULL LOAD
HOGGING-SAGGING

FREE-FLOATING DAMAGED CONDITION

Damaged Compartments:
LORG 4-106-2

	DISPLACEMENT LTons	DRAFT FWD ft	DRAFT AFT ft	TRIM ft	HEEL deg.	UPRIGHT GMt ft
INTACT	48,937	27.71	27.91	0.20A	0.1S	11.94
DAMAGED	48,923	22.06	26.59	4.53A	0.1S	8.01

SECTION AMIDSHIPS
(Looking Forward)

SHEAR & LONGITUDINAL BENDING STRESS SUMMARY
Stresses in ksi

FAIRED LINES PLAN

Wave Height: 33.09 ft   Wave Position: 452.50A ft-FP
Wave Length: 905.00 ft

(Based on Direct Calculation from Hull Offsets)
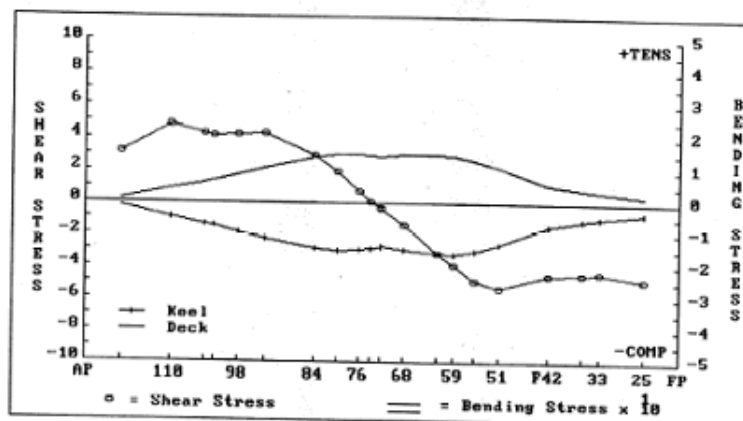
SHEAR & LONGITUDINAL BENDING STRESS SUMMARY
Stresses in ksi

FAIRED LINES PLAN

		SHEAR FORCES		BENDING MOMENTS		
	LOCATION	SHEAR	SHEAR STRESS	MOMENT	DK STRESS	KL STRESS
No.	ft-FP	LTons	ksi	ft-LTons	ksi	ksi
25	55.00A	-1,988	-4.82	66,784H	2.10	-3.25
33	121.00A	-4,263	-4.41	271,310H	3.26	-4.80
36	148.00A	-5,369	-4.50	401,515H	4.01	-5.64
F42	199.00A	-7,353	-4.53	727,348H	5.49	-7.35
51	274.00A	-7,838	-5.36	1,320,602H	10.82	-13.16
55	310.00A	-6,977	-4.90	1,590,264H	13.26	-15.34
59	343.00A	-5,701	-3.94	1,799,801H	14.68	-16.23
62	367.00A	-4,854	-3.19	1,925,682H	14.95	-16.04
68	418.00A	-2,415	-1.42	2,120,795H	14.76	-15.03
MS	452.50A	-706	-0.39	2,169,448H	14.11	-13.97
72	454.00A	-647	-0.36	2,170,452H	14.15	-14.02
Mx	469.75A	0	0.00	2,176,067H	14.53	-14.49
76	487.00A	1,148	0.66	2,166,954H	14.83	-14.93
80	520.00A	3,210	1.90	2,094,060H	14.77	-15.14
84	556.00A	4,947	2.94	1,945,092H	13.91	-14.56
93	631.00A	7,270	4.28	1,456,078H	10.53	-11.56
98	673.00A	7,177	4.17	1,155,805H	8.34	-9.41
F98	709.00A	7,127	4.10	897,635H	6.47	-7.47
104	724.00A	7,039	4.28	791,509H	6.02	-6.99
110	775.00A	6,290	4.75	448,278H	4.18	-5.00
126	851.00A	2,645	3.11	67,331H	0.95	-1.24

Maximum Shear Stress at 51:   -5.36 ksi
Maximum Deck Bending Stress at 62:   14.95 ksi
Maximum Keel Bending Stress at 59:   -16.23 ksi

FREE-FLOATING DAMAGED CONDITION

Damaged Compartments:
LORG 4-106-2

	DISPLACEMENT LTons	DRAFT FWD ft	DRAFT AFT ft	TRIM ft	HEEL deg.	UPRIGHT GMt ft
INTACT	48,937	27.71	27.91	0.20A	0.1S	11.94
DAMAGED	48,923	36.77	25.93	10.85F	0.0S	20.55

AP 126 110 F98 93 84 76 60 62 55 F42 36 25 FP

SECTION AMIDSHIPS
(Looking Forward)

HEEL (degrees-Stbd)

SHEAR & LONGITUDINAL BENDING STRESS SUMMARY
Stresses in ksi

FAIRED LINES PLAN

Wave Height: 33.09 ft   Wave Position: 0.00 ft-FP
Wave Length: 905.00 ft

(Based on Direct Calculation from Hull Offsets)
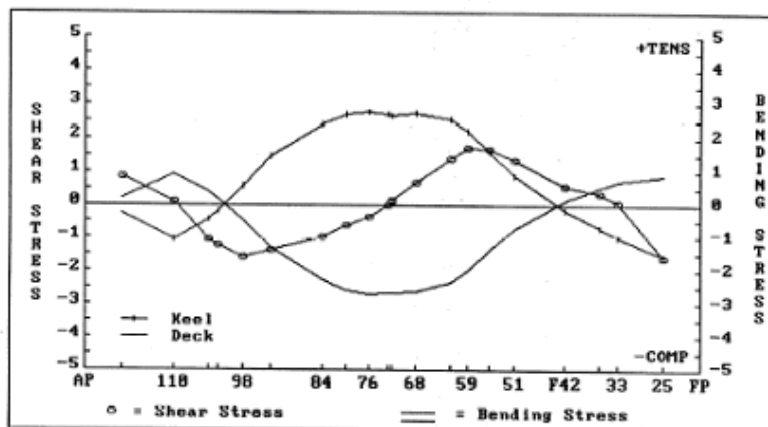
SHEAR & LONGITUDINAL BENDING STRESS SUMMARY
Stresses in ksi

FAIRED LINES PLAN

| | LOCATION | SHEAR FORCES | | BENDING MOMENTS | | |
No.	ft-FP	SHEAR LTons	SHEAR STRESS ksi	MOMENT ft-LTons	DK STRESS ksi	KL STRESS ksi
25	55.00A	-656	-1.59	32,250H	0.87	-1.57
33	121.00A	66	0.07	56,724H	0.68	-1.00
36	148.00A	399	0.33	50,651H	0.50	-0.71
F42	199.00A	873	0.54	16,856H	0.13	-0.17
51	274.00A	1,984	1.36	87,756S	-0.72	0.87
55	310.00A	2,352	1.65	166,520S	-1.39	1.60
59	343.00A	2,467	1.70	246,393S	-2.01	2.22
62	367.00A	2,097	1.38	302,491S	-2.34	2.52
68	418.00A	1,152	0.68	381,173S	-2.65	2.70
MS	452.50A	212	0.12	408,341S	-2.65	2.63
72	454.00A	154	0.08	408,634S	-2.66	2.64
Mx	457.95A	-0	-0.00	409,000S	-2.68	2.66
76	487.00A	-643	-0.37	397,695S	-2.72	2.74
80	520.00A	-1,046	-0.62	369,547S	-2.60	2.67
84	556.00A	-1,656	-0.98	320,452S	-2.29	2.40
93	631.00A	-2,363	-1.39	182,432S	-1.32	1.45
98	693.00A	-2,748	-1.60	68,155S	-0.49	0.55
P98	709.00A	-2,171	-1.25	22,140H	0.16	-0.18
104	724.00A	-1,761	-1.07	51,922H	0.39	-0.46
110	775.00A	100	0.08	95,313H	0.90	-1.07
126	851.00A	725	0.85	14,105H	0.20	-0.26

Maximum Shear Stress at 59:   1.70 ksi
Maximum Deck Bending Stress at 76:   -2.72 ksi
Maximum Keel Bending Stress at 76:   2.74 ksi

STILLWATER MOC

STATICAL STABILITY

FAIRED LINES PLAN
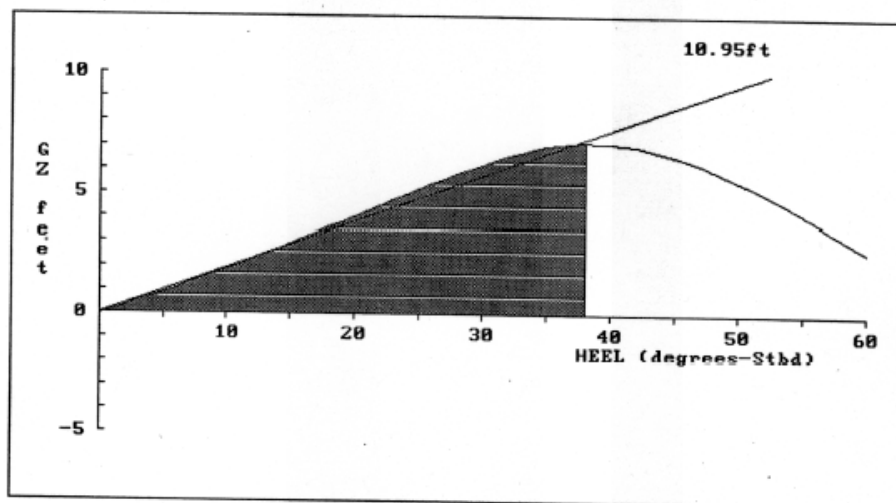
Angle of Heel	0.4 deg-S
Angle at Maximum GZ	38.3 deg
Area to 38.3 degrees	145.93 ft-deg
Maximum GZ	7.13 ft

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SHEAR & LONGITUDINAL BENDING STRESS SUMMARY
Stresses in ksi

FAIRED LINES PLAN
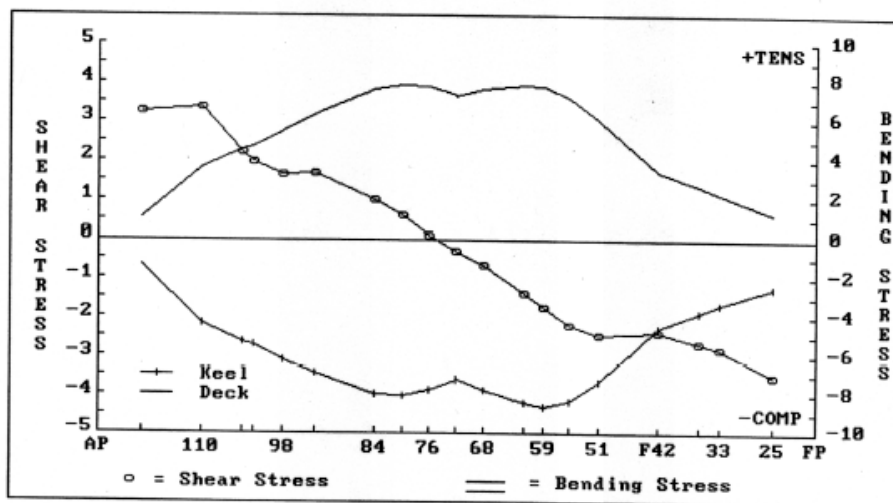
		SHEAR FORCES		BENDING MOMENTS		
	LOCATION	SHEAR	SHEAR STRESS	MOMENT	DK STRESS	KL STRESS
No.	ft-FP	LTons	ksi	ft-LTons	ksi	ksi
25	55.00A	-1,455	-3.53	50,711H	1.22	-2.46
33	121.00A	-2,712	-2.80	190,359H	2.28	-3.36
36	148.00A	-3,183	-2.66	270,258H	2.69	-3.79
F42	199.00A	-3,893	-2.40	451,894H	3.40	-4.56
51	274.00A	-3,577	-2.45	741,861H	6.06	-7.38
55	310.00A	-3,143	-2.21	863,861H	7.18	-8.32
59	343.00A	-2,519	-1.74	957,613H	7.79	-8.62
62	367.00A	-2,090	-1.37	1,012,554H	7.84	-8.42
68	418.00A	-1,132	-0.67	1,097,733H	7.62	-7.76
MS	452.50A	-564	-0.31	1,124,474H	7.30	-7.23
72	454.00A	-546	-0.30	1,125,291H	7.32	-7.25
76	487.00A	137	0.08	1,134,199H	7.75	-7.80
80	520.00A	1,009	0.60	1,115,046H	7.85	-8.04
84	556.00A	1,683	1.00	1,066,152H	7.61	-7.97
93	631.00A	2,814	1.66	876,269H	6.32	-6.94
98	673.00A	2,811	1.63	763,270H	5.50	-6.20
F98	709.00A	3,367	1.94	652,299H	4.69	-5.42
104	724.00A	3,630	2.21	600,003H	4.55	-5.29
110	775.00A	4,452	3.36	391,831H	3.65	-4.37
126	851.00A	2,748	3.23	72,141H	1.02	-1.32

Maximum Shear Stress at 25:   -3.53 ksi
Maximum Deck Bending Stress at 80:   7.85 ksi
Maximum Keel Bending Stress at 59:   -8.62 ksi
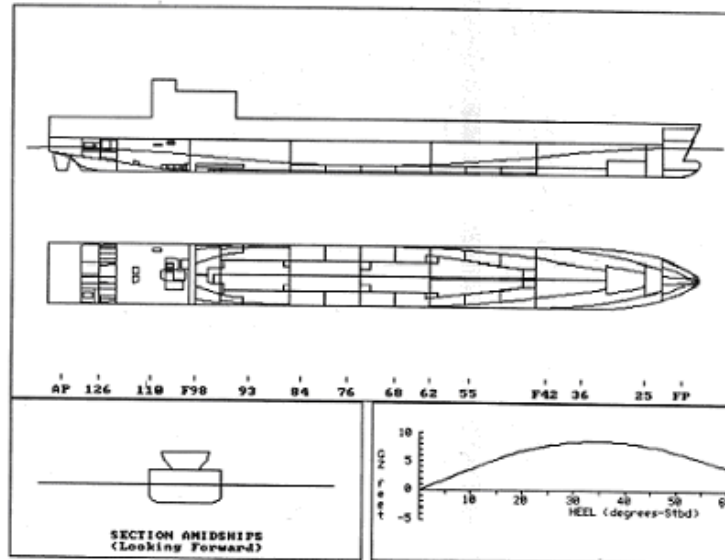
STILLWATER MOC
WIND

BEAM WIND with ROLLING STABILITY EVALUATION
(per U.S. Navy DDS079-1)

FAIRED LINES PLAN
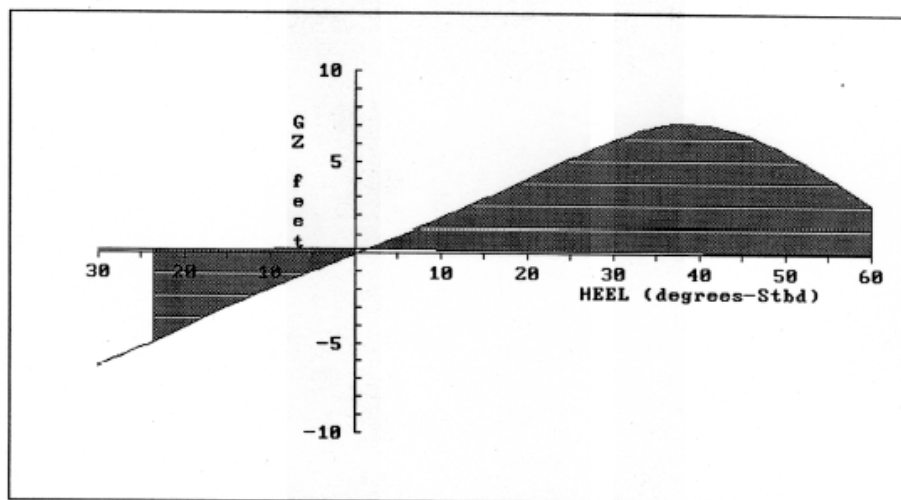
	Available	Required
Wind Heeling Arm Lw	0.20 ft	
Maximum Righting Arm	7.13 ft	0.33 ft
Capsizing Area A2	58.7 ft-deg	
Righting Area A1	256.0 ft-deg	82.2 ft-deg

Wind Velocity	=	100 knots	Mean Draft	=	26.69 ft
Wind Pressure Factor=		0.0035	Displacement	=	46,452 LTons
Wind Pressure	=	0.0156 LT/ft2	GMt (corrected)	=	10.95 ft
Projected Sail Area =		20421.9 ft2	Roll Angle	=	25.0 deg
Vertical Arm	=	42.31 ft ABL			
Heeling Arm at 0 deg=		0.20 ft	Angle at Intercept=		60.0 deg
Wind Heel Arm Lw	=	0.20 ft	Maximum GZ	=	7.13 ft
Wind Heel Angle	=	1.4 deg	Angle at Max. GZ	=	38.3 deg

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STILLWATER MOC
TURN

EFFECT on STABILITY of HIGH SPEED TURNING
(per U.S. Navy DDS079-1)

FAIRED LINES PLAN
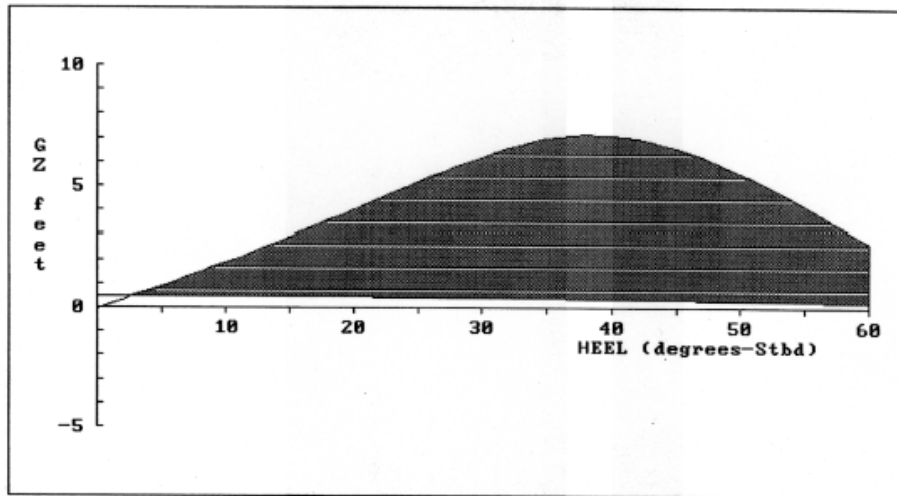
	Available	Required
Angle of Heel	2.8 deg	15.0 deg
Heeling Arm Lc	0.47 ft	
Maximum Righting Arm	7.13 ft	0.78 ft
Total Righting Area	264.2 ft-deg	
Reserve Righting Area	241.7 ft-deg	105.7 ft-deg

Ship Speed in Turn =	24.0 knots	Displacement	= 46,452 LTons
Turn Circle Radius =	3000 ft	VCG	= 40.92 ft
Heeling Arm at 0 deg=	0.47 ft	Mean Draft	= 26.69 ft

Angle at Max. GZ   =   38.3 deg

Positive GZ Range =   60.0 deg
Angle at Intercept=   60.0 deg

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INTACT MOC

FREE-FLOATING DAMAGED CONDITION

Damaged Compartments:
LORG 4-106-2

	DISPLACEMENT LTons	DRAFT FWD ft	DRAFT AFT ft	TRIM ft	HEEL deg.	UPRIGHT GMt ft
INTACT	46,452	26.87	26.52	0.35F	0.4S	10.95
DAMAGED	46,443	21.48	24.55	3.06A	0.6S	6.79
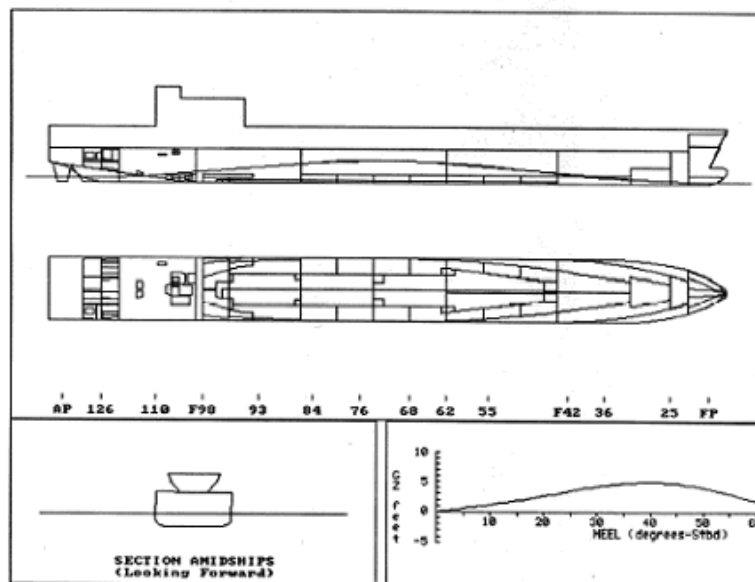
SECTION AMIDSHIPS
(Looking Forward)

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SHEAR & LONGITUDINAL BENDING STRESS SUMMARY
Stresses in ksi

FAIRED LINES PLAN

Wave Height: 33.09 ft   Wave Position: 452.50A ft-PP
Wave Length: 905.00 ft
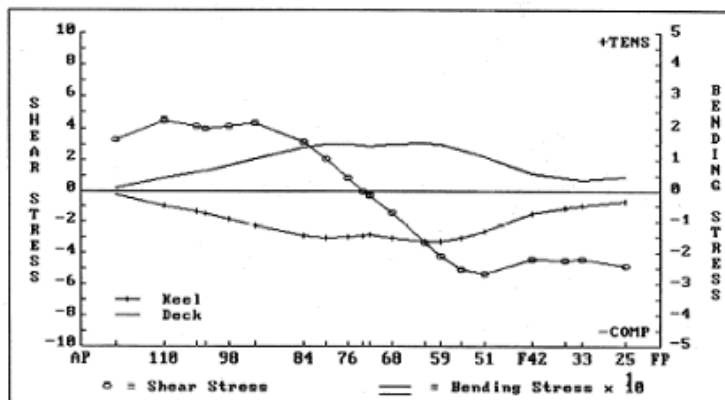
(Based on Direct Calculation from Hull Offsets)

SHEAR & LONGITUDINAL BENDING STRESS SUMMARY
Stresses in ksi

FAIRED LINES PLAN

		SHEAR FORCES		BENDING MOMENTS		
	LOCATION	SHEAR	SHEAR STRESS	MOMENT	DK STRESS	KL STRESS
No.	ft-FP	LTons	ksi	ft-LTons	ksi	ksi
25	55.00A	-1,996	-4.85	66,977H	4.37	-3.31
33	121.00A	-4,274	-4.42	272,673H	3.33	-4.87
36	148.00A	-5,313	-4.45	402,301H	4.07	-5.70
F42	199.00A	-7,139	-4.40	721,417H	5.51	-7.35
51	274.00A	-7,759	-5.31	1,299,450H	10.77	-13.08
55	310.00A	-7,171	-5.04	1,571,067H	13.25	-15.31
59	343.00A	-6,034	-4.17	1,789,686H	14.76	-16.31
62	367.00A	-5,030	-3.31	1,922,502H	15.09	-16.18
68	418.00A	-2,418	-1.42	2,118,542H	14.90	-15.17
MS	452.50A	-547	-0.30	2,166,205H	14.23	-14.09
72	454.00A	-471	-0.26	2,166,956H	14.27	-14.14
Mx	463.34A	-0	-0.00	2,169,283H	14.48	-14.41
76	487.00A	1,469	0.85	2,153,703H	14.89	-14.98
80	520.00A	3,501	2.07	2,070,690H	14.75	-15.12
84	556.00A	5,206	3.09	1,911,810H	13.81	-14.45
93	631.00A	7,332	4.32	1,409,583H	10.30	-11.29
98	673.00A	7,079	4.12	1,109,981H	8.09	-9.11
F98	709.00A	6,953	4.00	856,377H	6.23	-7.19
104	724.00A	6,813	4.14	753,236H	5.78	-6.71
110	775.00A	5,904	4.46	425,364H	4.01	-4.79
126	851.00A	2,747	3.23	68,790M	0.99	-1.28

Maximum Shear Stress at 51:   -5.31 ksi
Maximum Deck Bending Stress at 62:   15.09 ksi
Maximum Keel Bending Stress at 59:   -16.31 ksi

FREE-FLOATING DAMAGED CONDITION

Damaged Compartments:
LORD 4-106-2

	DISPLACEMENT LTons	DRAFT FWD ft	DRAFT AFT ft	TRIM ft	HEEL deg.	UPRIGHT GMt ft
INTACT	46,452	26.87	26.52	0.35F	0.4S	10.95
DAMAGED	46,443	35.82	24.90	10.92F	0.2S	19.99

AP 126 110 F98 93   84   76   68 62 55   F42 36   25 FP

SECTION AMIDSHIPS
(Looking Forward)

HEEL (degrees=Stbd)

SHEAR & LONGITUDINAL BENDING STRESS SUMMARY
Stresses in ksi

FAIRED LINES PLAN

Wave Height: 33.09 ft   Wave Position: 0.00 ft-FP
Wave Length: 905.00 ft

(Based on Direct Calculation from Hull Offsets)
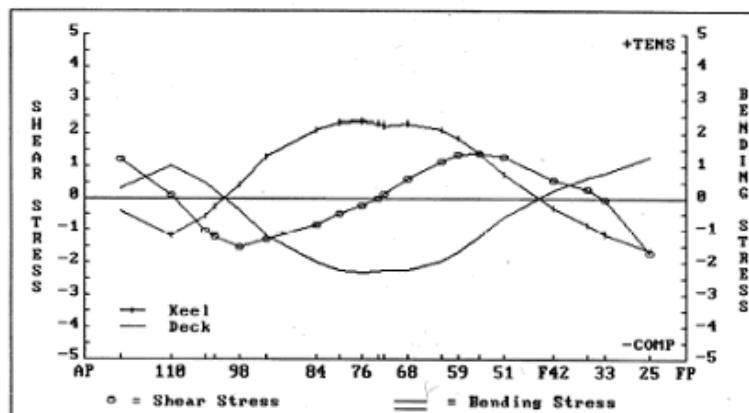
SHEAR & LONGITUDINAL BENDING STRESS SUMMARY
Stresses in ksi

FAIRED LINES PLAN

		SHEAR FORCES		BENDING MOMENTS		
	LOCATION	SHEAR	SHEAR STRESS	MOMENT	DK STRESS	KL STRESS
No.	ft-FP	LTons	ksi	ft-LTons	ksi	ksi
25	55.00A	-701	-1.70	33,302H	1.26	-1.62
33	121.00A	-64	-0.07	63,967H	0.77	-1.13
36	148.00A	300	0.25	61,027H	0.61	-0.86
F42	199.00A	880	0.54	29,858H	0.23	-0.30
51	274.00A	1,835	1.26	73,240S	-0.60	0.73
55	310.00A	1,941	1.36	141,993S	-1.19	1.37
59	343.00A	1,934	1.34	205,912S	-1.68	1.86
62	367.00A	1,735	1.14	250,464S	-1.95	2.09
68	418.00A	999	0.59	319,621S	-2.23	2.27
M8	452.50A	253	0.14	343,142S	-2.24	2.21
72	454.00A	213	0.12	343,509S	-2.24	2.22
Mx	461.79A	-0	-0.00	344,480S	-2.28	2.26
76	487.00A	-403	-0.23	339,037S	-2.32	2.34
80	520.00A	-796	-0.47	318,956S	-2.35	2.31
84	556.00A	-1,389	-0.82	279,163S	-2.00	2.09
93	631.00A	-2,170	-1.28	159,394S	-1.16	1.27
98	673.00A	-2,636	-1.53	51,580S	-0.37	0.42
F98	709.00A	-2,059	-1.18	34,371H	0.25	-0.29
104	724.00A	-1,670	-1.02	62,616H	0.48	-0.55
110	775.00A	107	0.08	103,655H	0.97	-1.16
126	851.00A	1,037	1.21	22,660H	0.32	-0.42

Maximum Shear Stress at 25:   -1.70 ksi
Maximum Deck Bending Stress at 76:   -2.32 ksi
Maximum Keel Bending Stress at 76:   2.34 ksi

Appendix F
POSSE Damaged Strength Analysis

STILLWATER FULL LOAD
FWD DAMAGE

FREE-FLOATING DAMAGED CONDITION

ITEM	WEIGHT LTons	KG ft-BL	LCG ft-FP	TCG ft-CL	FSmom ft-LTons
Light Ship	37,681	45.57	441.70A	0.65S	
Constant	0	0.00	452.50A	0.00	0
RoRo Cargo	0	0.00	452.50A	0.00	
Misc. Weight	1,861	36.63	437.82A	0.00	0
Fuel Oil	546	6.78	545.50A	0.02S	306
Diesel Oil	5,404	19.97	547.16A	0.65P	8,265
Lube Oil	134	47.08	837.03A	45.62S	34
Fresh Water	230	48.22	838.49A	38.66P	97
SW Ballast	2,625	12.68	645.23A	7.86P	7,737
Misc.	456	19.15	758.59A	6.57S	674
TOTALS	48,937	39.98	471.18A	0.01S	17,112

		INTACT	AFTER OUTFLOW	AS DAMAGED
Draft at F.P.	(ft)	27.71	----	26.97
Draft at A.P.	(ft)	27.91	----	30.23
Trim	(ft)	0.20A	----	3.26A
Draft at Fwd Marks	(ft)	27.72	----	27.04
Draft at Aft Marks	(ft)	27.91	----	30.14
Static Heel Angle	(deg)	0.1S	----	0.1P
Total Weight	(LT)	48,937	45,675	50,943
KG	(ft)	39.98	40.03	38.02
LCG	(ft-FP)	471.18A	444.91A	479.00A
TCG	(ft-CL)	0.01S	0.01P	0.02P
Buoyancy	(LT)	48,937	----	50,943
KB	(ft)	----	----	15.95
LCB	(ft-FP)	470.69A	----	479.08A
TCB	(ft-CL)	----	----	0.06P
KMt	(ft)	52.27	----	48.69
FSc	(ft)	0.35	----	0.24
GMt	(ft)	11.94	----	8.12
Shear Force	(LT)	----	----	4,449
Bending Moment	(ft-LT)	----	----	1,086,867H

AFTER OUTFLOW CONDITION:
  Displacement, KG, LCG, TCG include the effects of fluid outflow & flooding without free-communication.
AS DAMAGED CONDITION:
  Displacement, KG, LCG, TCG include the effects of the flooded water at the equilibrium trim/heel.
  Buoyancy, KB, LCB, TCB are for an intact hull at the equilibrium heel and drafts.
  KMt is for the damaged hull at the upright flooded drafts. GMt is the slope of the GZ curve at 0 degrees.
  F.S. correction accounts for the free surface of intact tanks and is corrected for outflow.

FREE-FLOATING DAMAGED CONDITION

Damaged Compartments:

FOCSLE	FPK 6--12-0	FB 8--11-0	HOLD 1	BOW THRUSTER	NO1 8-25-0
DP 8-32-1	DP 8-32-2				

	DISPLACEMENT LTons	DRAFT FWD ft	DRAFT AFT ft	TRIM ft	HEEL deg.	UPRIGHT GMt ft
INTACT	48,937	27.71	27.91	0.20A	0.1S	11.94
DAMAGED	54,325	38.92	22.46	16.46F	0.1S	11.16
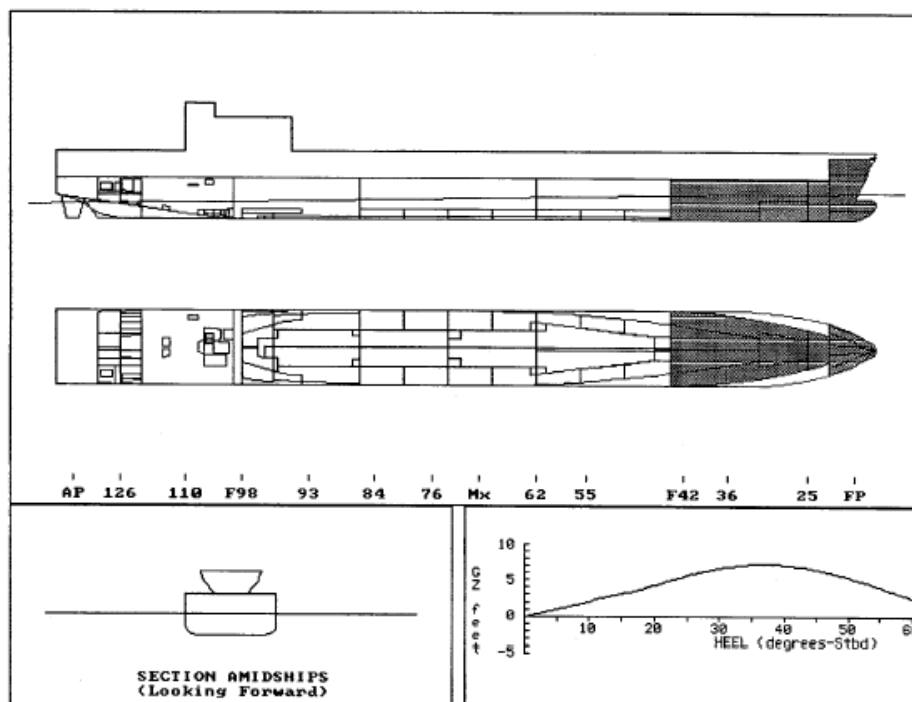
| AP | 126 | 110 | F98 | 93 | 84 | 76 | Mx | 62 | 55 | F42 | 36 | 25 | FP |

SECTION AMIDSHIPS
(Looking Forward)

SHEAR & LONGITUDINAL BENDING STRESS SUMMARY
Stresses in ksi

FAIRED LINES PLAN
(Based on Direct Calculation from Hull Offsets)
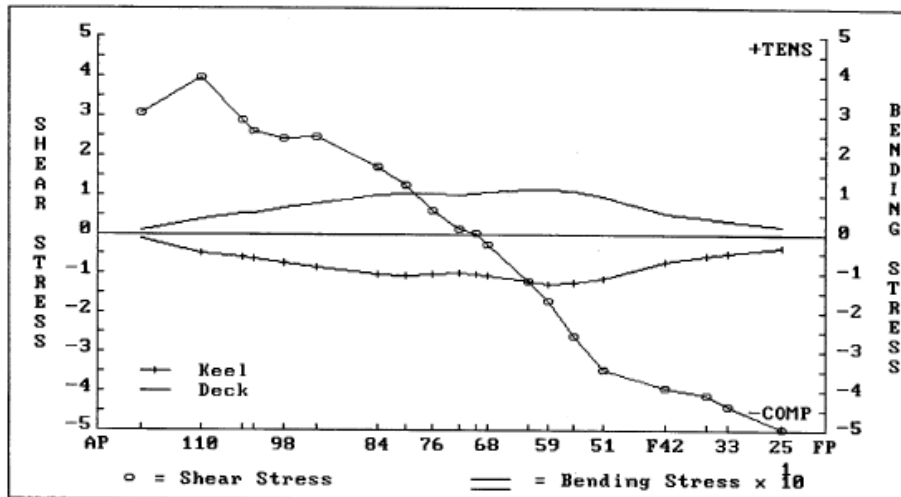
		SHEAR FORCES		BENDING MOMENTS		
	LOCATION	SHEAR	SHEAR STRESS	MOMENT	DK STRESS	KL STRESS
No.	ft-FP	LTons	ksi	ft-LTons	ksi	ksi
25	55.00A	-2,040	-4.95	67,248H	1.86	-3.26
33	121.00A	-4,230	-4.37	274,630H	3.30	-4.86
36	148.00A	-4,893	-4.10	397,816H	3.96	-5.58
F42	199.00A	-6,361	-3.92	683,609H	5.15	-6.90
51	274.00A	-5,049	-3.45	1,141,902H	9.34	-11.37
55	310.00A	-3,721	-2.61	1,300,856H	10.83	-12.54
59	343.00A	-2,448	-1.69	1,402,372H	11.42	-12.63
62	367.00A	-1,844	-1.21	1,452,545H	11.26	-12.09
68	418.00A	-473	-0.28	1,517,658H	10.55	-10.75
Mx	432.45A	1	0.00	1,520,793H	10.27	-10.33
MS	452.50A	240	0.13	1,517,254H	9.86	-9.76
72	454.00A	253	0.14	1,516,868H	9.88	-9.79
76	487.00A	1,015	0.58	1,499,482H	10.25	-10.32
80	520.00A	2,078	1.23	1,448,080H	10.20	-10.46
84	556.00A	2,881	1.71	1,358,169H	9.70	-10.16
93	631.00A	4,161	2.45	1,071,918H	7.74	-8.50
98	673.00A	4,142	2.41	902,411H	6.51	-7.34
F98	709.00A	4,538	2.61	746,500H	5.37	-6.21
104	724.00A	4,733	2.88	677,145H	5.14	-5.98
110	775.00A	5,241	3.95	420,944H	3.92	-4.69
126	851.00A	2,611	3.07	67,219H	0.95	-1.24

Maximum Shear Stress at 25:   -4.95 ksi
Maximum Deck Bending Stress at 59:   11.42 ksi
Maximum Keel Bending Stress at 59:   -12.63 ksi

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RIGHTING ARM (GZ)
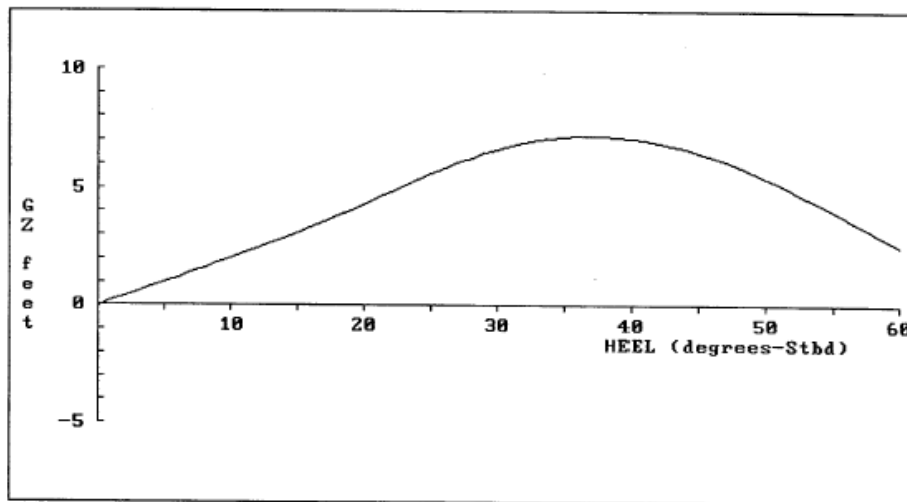
Stability Evaluation:

Static Heel Angle	0.1S deg	
Freeboard to Margin Line	53.65 ft	0.00 ft
Wind Heel Angle	0.9S deg	
Angle at Maximum GZ	37.0S deg	
Maximum GZ	7.19 ft	
Range of Positive GZ	>59.9 deg	
Gmt (upright damaged)	11.16 ft	

(Based on Direct Calculation from Hull Offsets)

Freeboards are calculated perpendicular to the water surface

SAGGING FULL LOAD
FWD DAMAGE

FREE-FLOATING DAMAGED CONDITION

Damaged Compartments:

FOCSLE	FPK 6--12-0	FB 8--11-0	HOLD 1	BOW THRUSTER	NO1 8-25-0
DP 8-32-1	DP 8-32-2				

	DISPLACEMENT LTons	DRAFT FWD ft	DRAFT AFT ft	TRIM ft	HEEL deg.	UPRIGHT GMt ft
INTACT	48,937	27.71	27.91	0.20A	0.1S	11.94
DAMAGED	60,247	56.55	18.21	38.34F	0.0S	17.28

SECTION AMIDSHIPS
(Looking Forward)

SHEAR & LONGITUDINAL BENDING STRESS SUMMARY
Stresses in ksi

FAIRED LINES PLAN

Wave Height: 33.09 ft   Wave Position: 0.00 ft-FP
Wave Length: 905.00 ft

(Based on Direct Calculation from Hull Offsets)
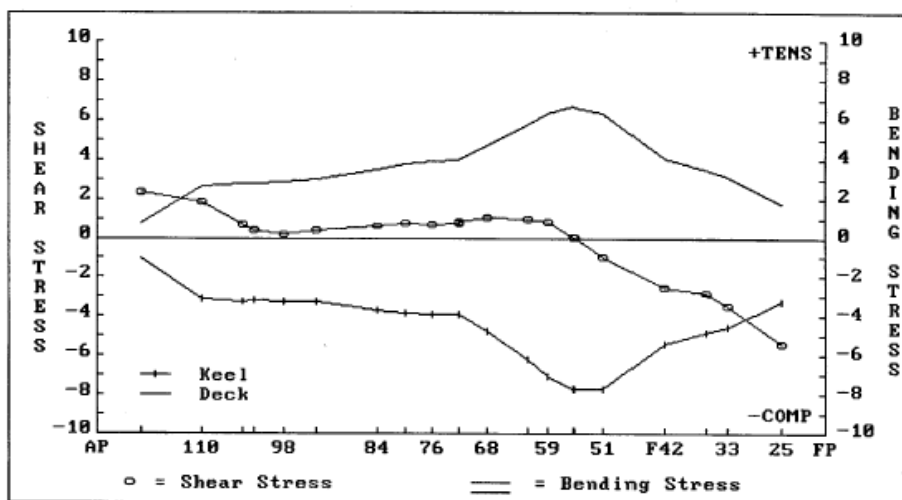
SHEAR & LONGITUDINAL BENDING STRESS SUMMARY
Stresses in ksi

FAIRED LINES PLAN

		SHEAR FORCES		BENDING MOMENTS		
	LOCATION	SHEAR	SHEAR STRESS	MOMENT	DK STRESS	KL STRESS
No.	ft-FP	LTons	ksi	ft-LTons	ksi	ksi
25	55.00A	-2,243	-5.44	67,306H	1.77	-3.27
33	121.00A	-3,343	-3.46	257,087H	3.09	-4.54
36	148.00A	-3,351	-2.81	347,472H	3.46	-4.87
F42	199.00A	-4,148	-2.56	533,250H	4.02	-5.38
51	274.00A	-1,457	-1.00	777,749H	6.36	-7.74
Mx	308.08A	0	0.00	801,738H	6.67	-7.74
55	310.00A	75	0.05	801,671H	6.67	-7.72
59	343.00A	1,165	0.80	780,572H	6.35	-7.03
62	367.00A	1,445	0.95	747,783H	5.80	-6.22
68	418.00A	1,711	1.01	670,492H	4.66	-4.75
MS	452.50A	1,456	0.80	611,909H	3.97	-3.93
72	454.00A	1,424	0.78	609,731H	3.97	-3.93
76	487.00A	1,176	0.68	569,419H	3.89	-3.92
80	520.00A	1,221	0.72	529,870H	3.73	-3.82
84	556.00A	987	0.59	490,218H	3.50	-3.66
93	631.00A	682	0.40	411,727H	2.97	-3.26
98	673.00A	297	0.17	397,558H	2.87	-3.23
F98	709.00A	745	0.43	380,197H	2.74	-3.16
104	724.00A	1,066	0.65	366,872H	2.78	-3.24
110	775.00A	2,459	1.86	278,021H	2.59	-3.10
126	851.00A	1,967	2.32	55,726H	0.79	-1.02

Maximum Shear Stress at 25:   -5.44 ksi
Maximum Deck Bending Stress at 55:   6.67 ksi
Maximum Keel Bending Stress at 51:   -7.74 ksi

RIGHTING ARM (GZ)
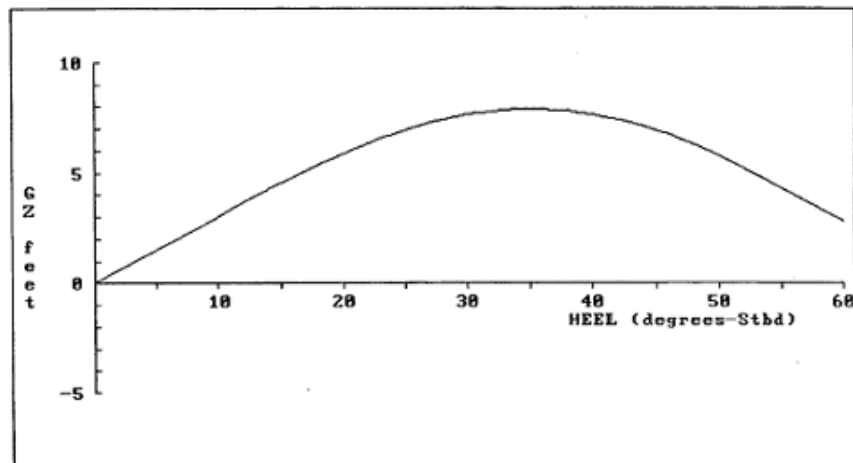
Stability Evaluation:
    Static Heel Angle   0.0S deg
    Freeboard to Margin Line   35.43 ft   0.00 ft
    Wind Heel Angle   0.4S deg
    Angle at Maximum GZ   35.1S deg
    Maximum GZ   7.90 ft
    Range of Positive GZ   >60.0   deg
    Gmt (upright damaged)   17.28 ft

(Based on Direct Calculation from Hull Offsets)
Freeboards are calculated perpendicular to the water surface

HOGGING FULL LOAD
FWD DAMAGE

FREE-FLOATING DAMAGED CONDITION

amaged Compartments:

| FOCSLE | FPK 6--12-0 | FB 8--11-0 | HOLD 1 | BOW THRUSTER | NO1 8-25-0 |
| DP 8-32-1 | DP 8-32-2 | | | | |

	DISPLACEMENT LTons	DRAFT FWD ft	DRAFT AFT ft	TRIM ft	HEEL deg.	UPRIGHT GMt ft
INTACT	48,937	27.71	27.91	0.20A	0.1S	11.94
DAMAGED	49,452	23.48	25.80	2.32A	0.1S	7.85

AP 126   110 F98   93   84   76   68 62 55   F42 36   25 FP

SECTION AMIDSHIPS
(Looking Forward)

SHEAR & LONGITUDINAL BENDING STRESS SUMMARY
Stresses in ksi

FAIRED LINES PLAN

Wave Height: 33.09 ft   Wave Position: 452.50A ft-FP
Wave Length: 905.00 ft

(Based on Direct Calculation from Hull Offsets)
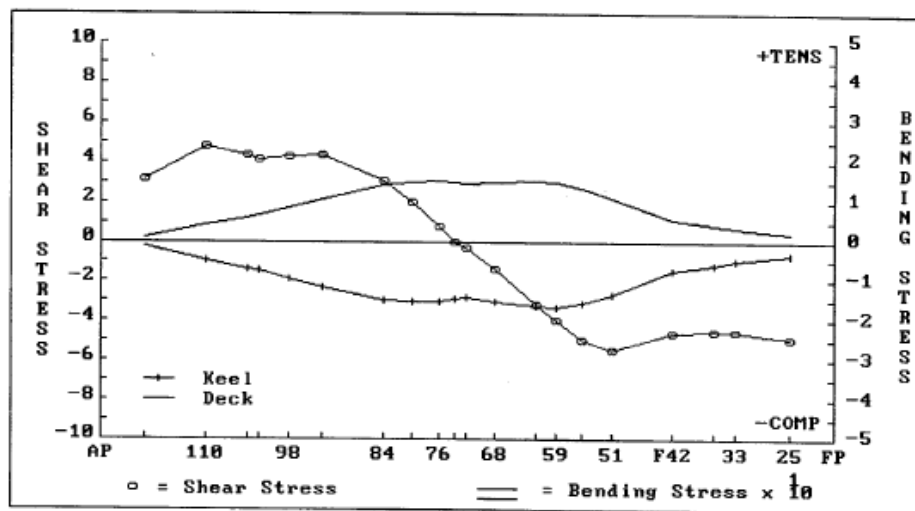
SHEAR & LONGITUDINAL BENDING STRESS SUMMARY
Stresses in ksi

FAIRED LINES PLAN

| | | SHEAR FORCES | | BENDING MOMENTS | | |
| | LOCATION | SHEAR | SHEAR STRESS | MOMENT | DK STRESS | KL STRESS |
No.	ft-FP	LTons	ksi	ft-LTons	ksi	ksi
25	55.00A	-2,031	-4.93	67,641H	1.97	-3.29
33	121.00A	-4,428	-4.58	279,632H	3.36	-4.95
36	148.00A	-5,474	-4.58	413,398H	4.12	-5.80
F42	199.00A	-7,542	-4.65	744,788H	5.62	-7.52
51	274.00A	-8,024	-5.49	1,356,654H	11.11	-13.51
55	310.00A	-7,088	-4.98	1,631,656H	13.59	-15.73
59	343.00A	-5,749	-3.97	1,843,795H	15.02	-16.62
62	367.00A	-4,863	-3.20	1,970,339H	15.28	-16.40
68	418.00A	-2,353	-1.38	2,164,020H	15.05	-15.33
MS	452.50A	-608	-0.33	2,209,874H	14.37	-14.22
72	454.00A	-546	-0.30	2,210,728H	14.41	-14.27
Mx	467.47A	-0	-0.00	2,214,672H	14.72	-14.67
76	487.00A	1,275	0.73	2,203,456H	15.07	-15.17
80	520.00A	3,356	1.98	2,126,035H	14.99	-15.36
84	556.00A	5,105	3.03	1,971,578H	14.09	-14.75
93	631.00A	7,421	4.37	1,470,757H	10.63	-11.67
98	673.00A	7,306	4.25	1,164,573H	8.40	-9.47
F98	709.00A	7,226	4.16	902,263H	6.50	-7.50
104	724.00A	7,124	4.33	794,749H	6.04	-7.02
110	775.00A	6,308	4.76	449,007H	4.19	-5.01
126	851.00A	2,649	3.12	67,471H	0.95	-1.24

Maximum Shear Stress at 51:   -5.49 ksi

Maximum Deck Bending Stress at 62:   15.28 ksi

Maximum Keel Bending Stress at 59:   -16.62 ksi

RIGHTING ARM (GZ)
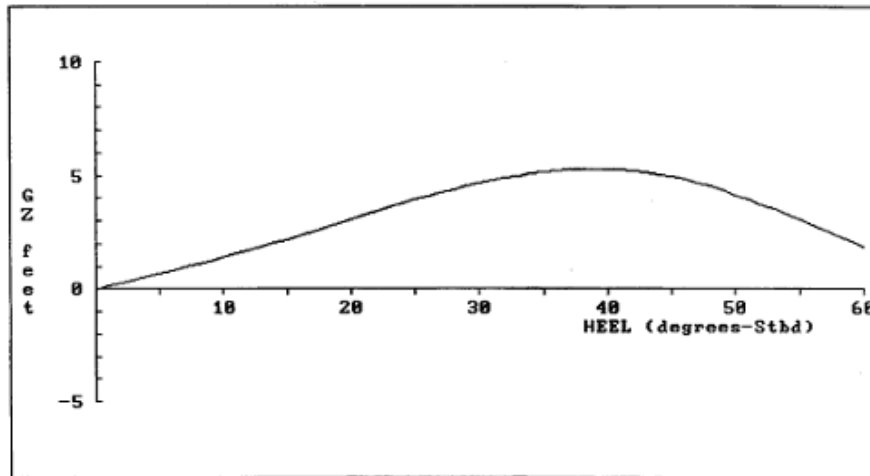
Stability Evaluation:

Static Heel Angle	0.1S deg	
Freeboard to Margin Line	67.08 ft	0.00 ft
Wind Heel Angle	1.6S deg	
Angle at Maximum GZ	39.0S deg	
Maximum GZ	5.29 ft	
Range of Positive GZ	>59.9 deg	
Gmt (upright damaged)	7.85 ft	

(Based on Direct Calculation from Hull Offsets)
Freeboards are calculated perpendicular to the water surface

STILLWATER FULL LOAD
MD DAMAGE

FREE-FLOATING DAMAGED CONDITION

Damaged Compartments:

HOLD 2	W2A 8-44-01	FB 8-44-1	W2A 8-44-4	FB 8-44-2	W2B 8-50-1
W2B 8-50-2	W2C 8-56-1	W2C 8-56-2	HOLD 3	W3A 8-62-1	DB3F 8-62-0
DB3F 8-62-2	W3A 8-62-4	W3B 8-68-1	W3B 8-68-2	N3C 8-74-1	DB3A 8-74-0
DB3A 8-74-2	W3C 8-74-4	W3D 8-80-1	W3D 8-80-2		

	DISPLACEMENT LTons	DRAFT FWD ft	DRAFT AFT ft	TRIM ft	HEEL deg.	UPRIGHT GMt ft
INTACT	48,937	27.71	27.91	0.20A	0.1S	11.94
DAMAGED	77,652	50.70	31.07	19.64F	0.6S	10.34

AP 126 110 F98   93   84   76   68 62 55   F42 36   25 FP

SECTION AMIDSHIPS
(Looking Forward)

HEEL (degrees-Stbd)

FREE-FLOATING DAMAGED CONDITION

ITEM	WEIGHT LTons	KG ft-BL	LCG ft-FP	TCG ft-CL	FSmom ft-LTons
Light Ship	37,681	45.57	441.70A	0.65S	
Constant	0	0.00	452.50A	0.00	0
RoRo Cargo	0	0.00	452.50A	0.00	
Misc. Weight	1,861	36.63	437.82A	0.00	0
Fuel Oil	546	6.78	545.50A	0.02S	306
Diesel Oil	5,404	19.97	547.16A	0.65P	8,265
Lube Oil	134	47.08	837.03A	45.62S	34
Fresh Water	230	48.22	838.49A	38.66P	97
SW Ballast	2,625	12.68	645.23A	7.86P	7,737
Misc.	456	19.15	758.59A	6.57S	674
TOTALS	48,937	39.98	471.18A	0.01S	17,112

		INTACT	AFTER OUTFLOW	AS DAMAGED
Draft at F.P.	(ft)	27.71	----	38.92
Draft at A.P.	(ft)	27.91	----	22.46
Trim	(ft)	0.20A	----	16.46F
Draft at Fwd Marks	(ft)	27.72	----	38.55
Draft at Aft Marks	(ft)	27.91	----	22.91
Static Heel Angle	(deg)	0.1S	----	0.1S
Total Weight	(LT)	48,937	47,640	54,325
KG	(ft)	39.98	40.81	38.37
LCG	(ft-FP)	471.18A	479.39A	436.54A
TCG	(ft-CL)	0.01S	0.01S	0.01S
Buoyancy	(LT)	48,937	----	54,325
KB	(ft)	----	----	17.10
LCB	(ft-FP)	470.69A	----	436.15A
TCB	(ft-CL)	----	----	0.03S
KMt	(ft)	52.27	----	52.53
FSc	(ft)	0.35	----	0.29
GMt	(ft)	11.94	----	11.16
Shear Force	(LT)	----	----	-6,361
Bending Moment	(ft-LT)	----	----	1,520,793H

AFTER OUTFLOW CONDITION:

 Displacement, KG, LCG, TCG include the effects of fluid outflow & flooding without free-communication.

AS DAMAGED CONDITION:

 Displacement, KG, LCG, TCG include the effects of the flooded water at the equilibrium trim/heel.

 Buoyancy, KB, LCB, TCB are for an intact hull at the equilibrium heel and drafts.

 KMt is for the damaged hull at the upright flooded drafts. GMt is the slope of the GZ curve at 0 degrees.

 F.S. correction accounts for the free surface of intact tanks and is corrected for outflow.

SHEAR & LONGITUDINAL BENDING STRESS SUMMARY
Stresses in ksi

FAIRED LINES PLAN
(Based on Direct Calculation from Hull Offsets)

o = Shear Stress   ══════ = Bending Stress
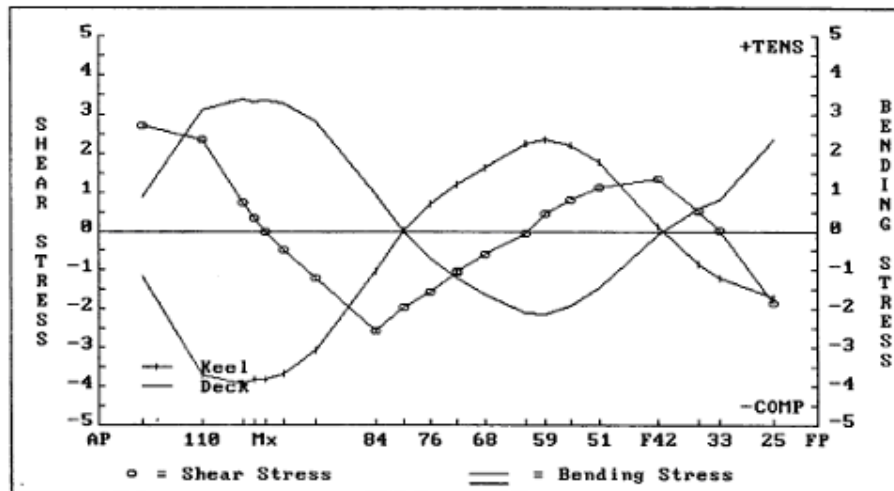
| | | SHEAR FORCES | | BENDING MOMENTS | | |
No.	LOCATION ft-FP	SHEAR LTons	SHEAR STRESS ksi	MOMENT ft-LTons	DK STRESS ksi	KL STRESS ksi
25	55.00A	-758	-1.84	34,808H	2.35	-1.72
33	121.00A	32	0.03	66,808H	0.82	-1.19
36	148.00A	626	0.52	58,525H	0.59	-0.83
F42	199.00A	2,182	1.34	10,824S	-0.08	0.11
51	274.00A	1,675	1.15	176,824S	-1.47	1.78
55	310.00A	1,135	0.80	226,890S	-1.92	2.21
59	343.00A	650	0.45	256,661S	-2.12	2.34
62	367.00A	-100	-0.07	264,782S	-2.08	2.23
68	418.00A	-1,028	-0.60	230,003S	-1.62	1.65
MS	452.50A	-1,867	-1.03	184,472S	-1.21	1.20
72	454.00A	-1,921	-1.06	181,646S	-1.20	1.19
76	487.00A	-2,724	-1.57	102,080S	-0.71	0.71
80	520.00A	-3,303	-1.95	3,022S	-0.02	0.02
84	556.00A	-4,304	-2.56	133,218H	0.96	-1.01
93	631.00A	-2,023	-1.19	383,910H	2.81	-3.08
98	673.00A	-835	-0.49	448,711H	3.27	-3.69
Mx	694.37A	-0	-0.00	457,877H	3.34	-3.81
F98	709.00A	580	0.33	453,587H	3.30	-3.81
104	724.00A	1,196	0.73	440,442H	3.38	-3.93
110	775.00A	3,116	2.35	328,533H	3.10	-3.70
126	851.00A	2,304	2.71	61,978H	0.89	-1.16

Maximum Shear Stress at 126:   2.71 ksi
Maximum Deck Bending Stress at 104:   3.38 ksi
Maximum Keel Bending Stress at 104:   -3.93 ksi

RIGHTING ARM (GZ)
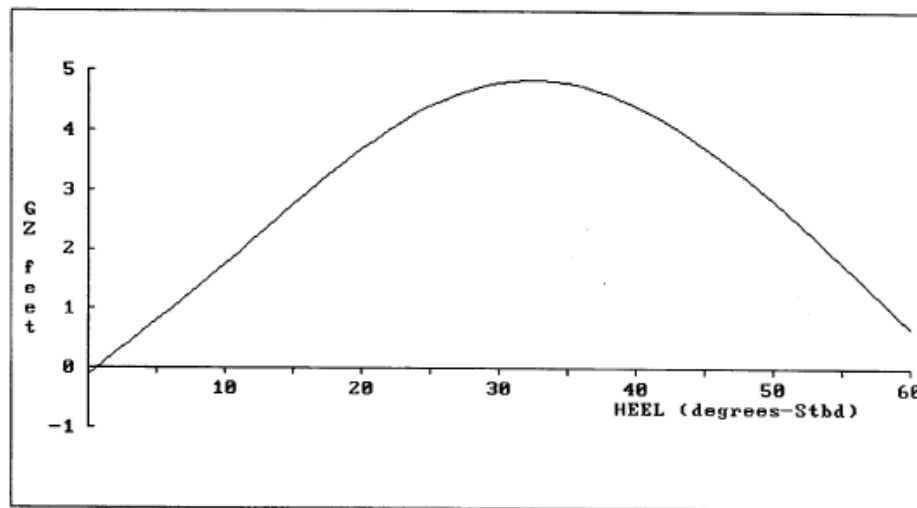
Stability Evaluation:

Static Heel Angle	0.6S deg	
Freeboard to Margin Line	41.78 ft	0.00 ft
Wind Heel Angle	1.1S deg	
Angle at Maximum GZ	32.3S deg	
Maximum GZ	4.83 ft	
Range of Positive GZ	>59.4 deg	
Gmt (upright damaged)	10.34 ft	

(Based on Direct Calculation from Hull Offsets)

Freeboards are calculated perpendicular to the water surface

HOGGING FULL LOAD
MD DAMAGE

FREE-FLOATING DAMAGED CONDITION

Damaged Compartments:

HOLD 2	W2A 8-44-01	FB 8-44-1	W2A 8-44-4	FB 8-44-2	W2B 8-50-1
W2B 8-50-2	W2C 8-56-1	W2C 8-56-2	HOLD 3	W3A 8-62-1	DB3F 8-62-0
DB3F 8-62-2	W3A 8-62-4	W3B 8-68-1	W3B 8-68-2	W3C 8-74-1	DB3A 8-74-0
DB3A 8-74-2	W3C 8-74-4	W3D 8-80-1	W3D 8-80-2		

	DISPLACEMENT LTons	DRAFT FWD ft	DRAFT AFT ft	TRIM ft	HEEL deg.	UPRIGHT GMt ft
INTACT	48,937	27.71	27.91	0.20A	0.1S	11.94
DAMAGED	87,412	53.25	33.62	19.63F	1.0S	6.55

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SHEAR & LONGITUDINAL BENDING STRESS SUMMARY
Stresses in ksi

FAIRED LINES PLAN

Wave Height: 33.09 ft   Wave Position: 452.50A ft-FP
Wave Length: 905.00 ft

(Based on Direct Calculation from Hull Offsets)
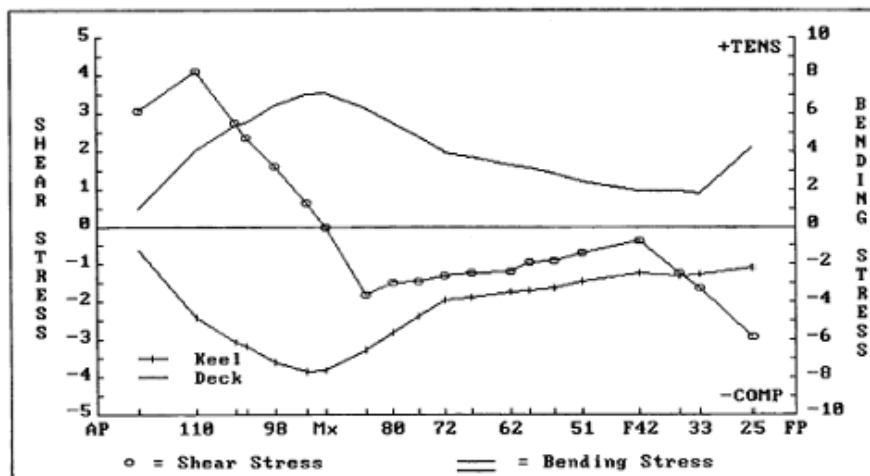
SHEAR & LONGITUDINAL BENDING STRESS SUMMARY
Stresses in ksi

FAIRED LINES PLAN

		SHEAR FORCES		BENDING MOMENTS		
	LOCATION	SHEAR	SHEAR STRESS	MOMENT	DK STRESS	KL STRESS
No.	ft-FP	LTons	ksi	ft-LTons	ksi	ksi
25	55.00A	-1,205	-2.92	44,044H	4.17	-2.20
33	121.00A	-1,585	-1.64	142,082H	1.76	-2.56
36	148.00A	-1,494	-1.25	184,348H	1.89	-2.63
F42	199.00A	-584	-0.36	241,986H	1.87	-2.49
51	274.00A	-1,023	-0.70	286,288H	2.40	-2.91
55	310.00A	-1,279	-0.90	329,171H	2.81	-3.24
59	343.00A	-1,390	-0.96	372,991H	3.11	-3.43
62	367.00A	-1,851	-1.22	410,014H	3.25	-3.48
68	418.00A	-2,129	-1.25	518,426H	3.68	-3.74
MS	452.50A	-2,378	-1.31	592,667H	3.93	-3.89
72	454.00A	-2,403	-1.32	596,250H	3.96	-3.92
76	487.00A	-2,547	-1.47	682,483H	4.76	-4.79
80	520.00A	-2,500	-1.48	764,343H	5.49	-5.63
84	556.00A	-3,030	-1.80	860,981H	6.27	-6.56
Mx	607.17A	-53	-0.03	966,288H	7.09	-7.66
93	631.00A	1,072	0.63	952,019H	7.01	-7.68
98	673.00A	2,735	1.59	874,682H	6.43	-7.24
F98	709.00A	4,076	2.34	751,056H	5.51	-6.35
104	724.00A	4,537	2.76	686,555H	5.32	-6.16
110	775.00A	5,447	4.11	426,914H	4.07	-4.85
126	851.00A	2,594	3.05	65,540H	0.95	-1.23

Maximum Shear Stress at 110: 4.11 ksi
Maximum Deck Bending Stress at Mx: 7.09 ksi
Maximum Keel Bending Stress at 93: -7.68 ksi

RIGHTING ARM (GZ)
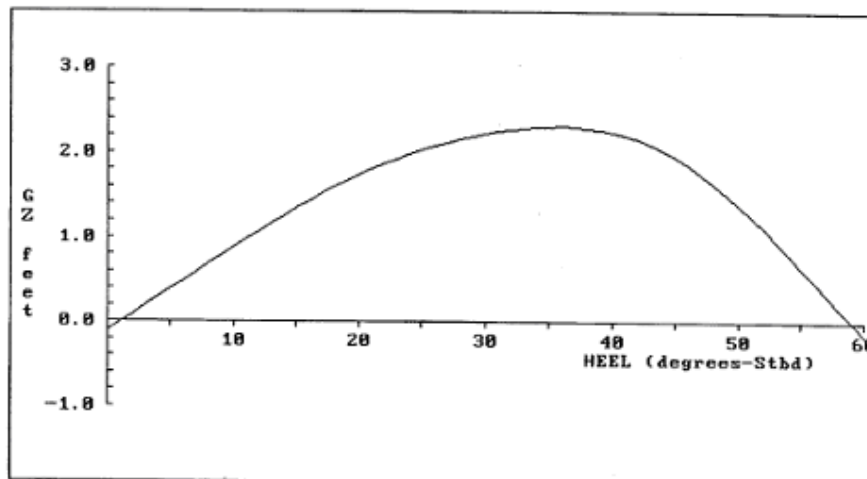
Stability Evaluation:

Static Heel Angle	1.0S deg	
Freeboard to Margin Line	39.22 ft	0.00 ft
Wind Heel Angle	1.7S deg	
Angle at Maximum GZ	35.7S deg	
Maximum GZ	2.31 ft	
Range of Positive GZ	58.0 deg	
Gmt (upright damaged)	6.55 ft	

(Based on Direct Calculation from Hull Offsets)
Freeboards are calculated perpendicular to the water surface

SAGGING FULL LOAD
MD DAMAGE

FREE-FLOATING DAMAGED CONDITION

Damaged Compartments:

HOLD 2	W2A 8-44-01	FB 8-44-1	W2A 8-44-4	FB 8-44-2	W2B 8-50-1
W2B 8-50-2	W2C 8-56-1	W2C 8-56-2	HOLD 3	W3A 8-62-1	DB3F 8-62-0
DB3F 8-62-2	W3A 8-62-4	W3B 8-68-1	W3B 8-68-2	W3C 8-74-1	DB3A 8-74-0
DB3A 8-74-2	W3C 8-74-4	W3D 8-80-1	W3D 8-80-2		

	DISPLACEMENT LTons	DRAFT FWD ft	DRAFT AFT ft	TRIM ft	HEEL deg.	UPRIGHT GMt ft
INTACT	48,937	27.71	27.91	0.20A	0.1S	11.94
DAMAGED	67,749	52.41	26.89	25.52F	0.4S	15.52
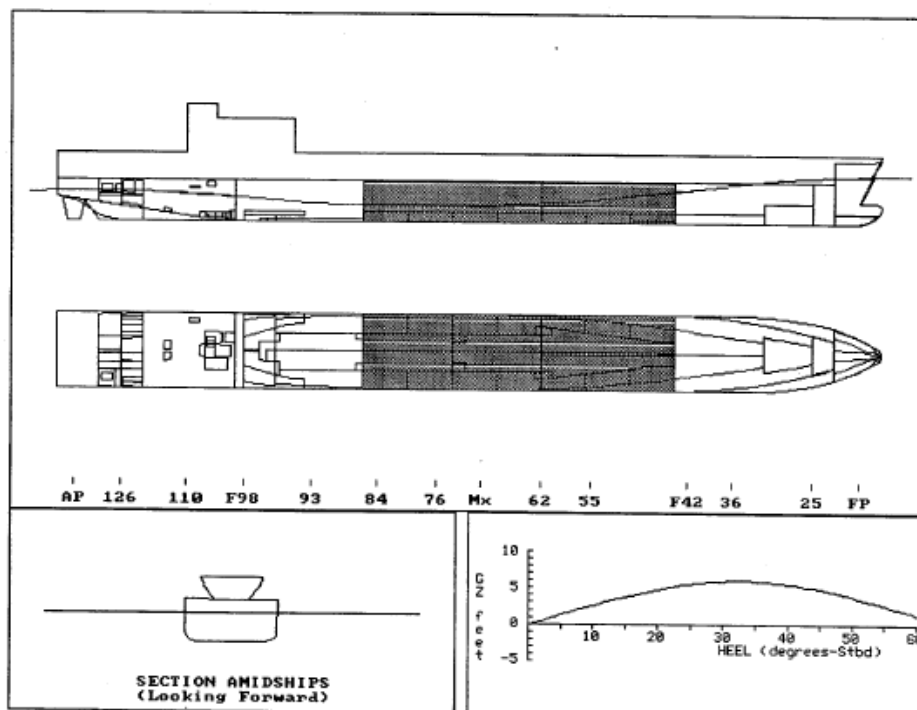
AP 126 110 F98 93 84 76 Mx 62 55 F42 36 25 FP

SECTION AMIDSHIPS
(Looking Forward)

SHEAR & LONGITUDINAL BENDING STRESS SUMMARY
Stresses in ksi

FAIRED LINES PLAN

Wave Height: 33.09 ft   Wave Position: 0.00   ft-FP
Wave Length: 905.00 ft

(Based on Direct Calculation from Hull Offsets)
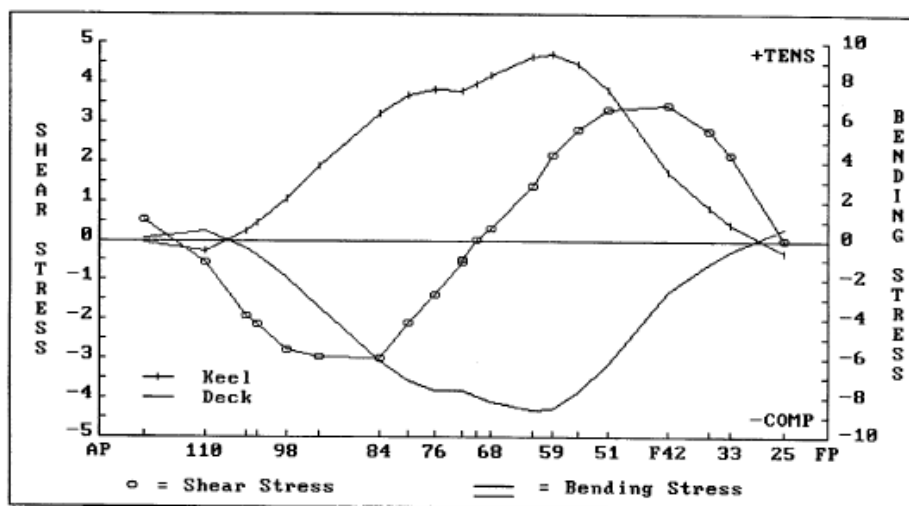
SHEAR & LONGITUDINAL BENDING STRESS SUMMARY
Stresses in ksi

FAIRED LINES PLAN

No.	LOCATION ft-FP	SHEAR FORCES		BENDING MOMENTS		
		SHEAR LTons	SHEAR STRESS ksi	MOMENT ft-LTons	DK STRESS ksi	KL STRESS ksi
25	55.00A	2	0.01	11,836H	0.63	-0.58
33	121.00A	2,088	2.16	44,647S	-0.54	0.80
36	148.00A	3,308	2.77	117,193S	-1.18	1.66
F42	199.00A	5,528	3.41	343,718S	-2.61	3.49
51	274.00A	4,872	3.33	759,918S	-6.27	7.62
55	310.00A	4,012	2.82	920,392S	-7.73	8.94
59	343.00A	3,158	2.18	1,038,607S	-8.53	9.43
62	367.00A	2,126	1.40	1,103,348S	-8.63	9.25
68	418.00A	539	0.32	1,167,652S	-8.18	8.33
Mx	436.04A	13	0.01	1,172,478S	-7.92	7.95
MS	452.50A	-899	-0.49	1,165,243S	-7.63	7.55
72	454.00A	-980	-0.54	1,163,850S	-7.64	7.57
76	487.00A	-2,388	-1.38	1,106,164S	-7.62	7.67
80	520.00A	-3,530	-2.08	1,008,395S	-7.16	7.34
84	556.00A	-5,017	-2.98	854,314S	-6.15	6.44
93	631.00A	-5,038	-2.97	471,215S	-3.43	3.76
98	673.00A	-4,779	-2.78	258,397S	-1.88	2.11
F98	709.00A	-3,719	-2.14	103,884S	-0.75	0.87
104	724.00A	-3,126	-1.90	52,279S	-0.40	0.46
110	775.00A	-739	-0.56	47,782H	0.45	-0.54
126	851.00A	454	0.53	5,948H	0.08	-0.11

```
Maximum Shear Stress at F42:        3.41 ksi
Maximum Deck Bending Stress at 62:  -8.63 ksi
Maximum Keel Bending Stress at 59:   9.43 ksi
```

RIGHTING ARM (GZ)
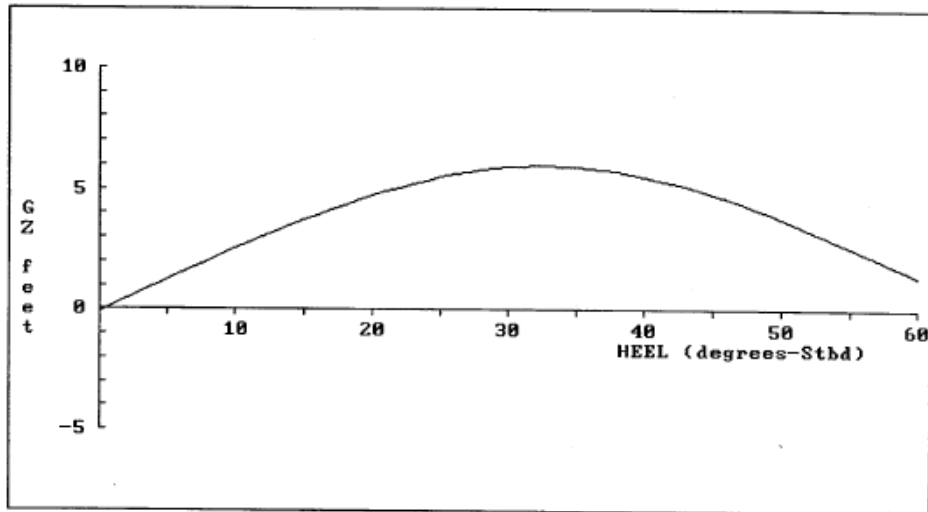
Stability Evaluation:

Static Heel Angle	0.4S deg	
Freeboard to Margin Line	39.91 ft	0.00 ft
Wind Heel Angle	0.8S deg	
Angle at Maximum GZ	32.5S deg	
Maximum GZ	5.98 ft	
Range of Positive GZ	>59.6 deg	
Gmt (upright damaged)	15.52 ft	

(Based on Direct Calculation from Hull Offsets)

Freeboards are calculated perpendicular to the water surface

FREE-FLOATING DAMAGED CONDITION

ITEM	WEIGHT LTons	KG ft-BL	LCG ft-FP	TCG ft-CL	FSmom ft-LTons
Light Ship	37,681	45.57	441.70A	0.65S	
Constant	0	0.00	452.50A	0.00	0
RoRo Cargo	0	0.00	452.50A	0.00	
Misc. Weight	1,861	36.63	437.82A	0.00	0
Fuel Oil	546	6.78	545.50A	0.02S	306
Diesel Oil	5,404	19.97	547.16A	0.65P	8,265
Lube Oil	134	47.08	837.03A	45.62S	34
Fresh Water	230	48.22	838.49A	38.66P	97
SW Ballast	2,625	12.68	645.23A	7.86P	7,737
Misc.	456	19.15	758.59A	6.57S	674
TOTALS	48,937	39.98	471.18A	0.01S	17,112

		INTACT	AFTER OUTFLOW	AS DAMAGED
Draft at F.P.	(ft)	27.71	----	50.70
Draft at A.P.	(ft)	27.91	----	31.07
Trim	(ft)	0.20A	----	19.64F
Draft at Fwd Marks	(ft)	27.72	----	50.27
Draft at Aft Marks	(ft)	27.91	----	31.61
Static Heel Angle	(deg)	0.1S	----	0.6S
Total Weight	(LT)	48,937	46,359	77,652
KG	(ft)	39.98	41.84	33.50
LCG	(ft-FP)	471.18A	472.12A	441.50A
TCG	(ft-CL)	0.01S	0.16S	0.16S
Buoyancy	(LT)	48,937	----	77,652
KB	(ft)	----	----	22.74
LCB	(ft-FP)	470.69A	----	441.27A
TCB	(ft-CL)	----	----	0.28S
KMt	(ft)	52.27	----	52.78
FSc	(ft)	0.35	----	0.32
GMt	(ft)	11.94	----	10.34
Shear Force	(LT)	----	----	-4,304
Bending Moment	(ft-LT)	----	----	457,877H

AFTER OUTFLOW CONDITION:
  Displacement, KG, LCG, TCG include the effects of fluid outflow & flooding without free-communication.
AS DAMAGED CONDITION:
  Displacement, KG, LCG, TCG include the effects of the flooded water at the equilibrium trim/heel.
  Buoyancy, KB, LCB, TCB are for an intact hull at the equilibrium heel and drafts.
  KMt is for the damaged hull at the upright flooded drafts. GMt is the slope of the GZ curve at 0 degrees.
  F.S. correction accounts for the free surface of intact tanks and is corrected for outflow

STILLWATER FULL LOAD
AFT DAMAGE

FREE-FLOATING DAMAGED CONDITION

Damaged Compartments:

MACHY	LODT 8-103-4	ERWO 8-104-0	LOSM 8-104-1	LOSM 8-105-2	LORG 4-106-2
LORG 4-106-4	GTWD 8-107-0	BOLR CASCADE	FPST 7-112-1	LOPS 7-112-2	AFT
RGS 5-116-11	DP 6-116-1	SSDG 5-116-9	RGSL 5-116-7	ST 5-116-3	DTA 6-116-0
ST 5-116-1	SV 5-116-0	DP 6-116-4	POT 5-116-6	POT 5-116-8	DIS 5-116-10
GWT 5-126-1	APF 6-126-1	APF 6-126-2	SWHT 5-130-1		

	DISPLACEMENT LTons	DRAFT FWD ft	DRAFT AFT ft	TRIM ft	HEEL deg.	UPRIGHT GMt ft
INTACT	48,937	27.71	27.91	0.20A	0.1S	11.94
DAMAGED	50,943	26.97	30.23	3.26A	0.1P	8.12
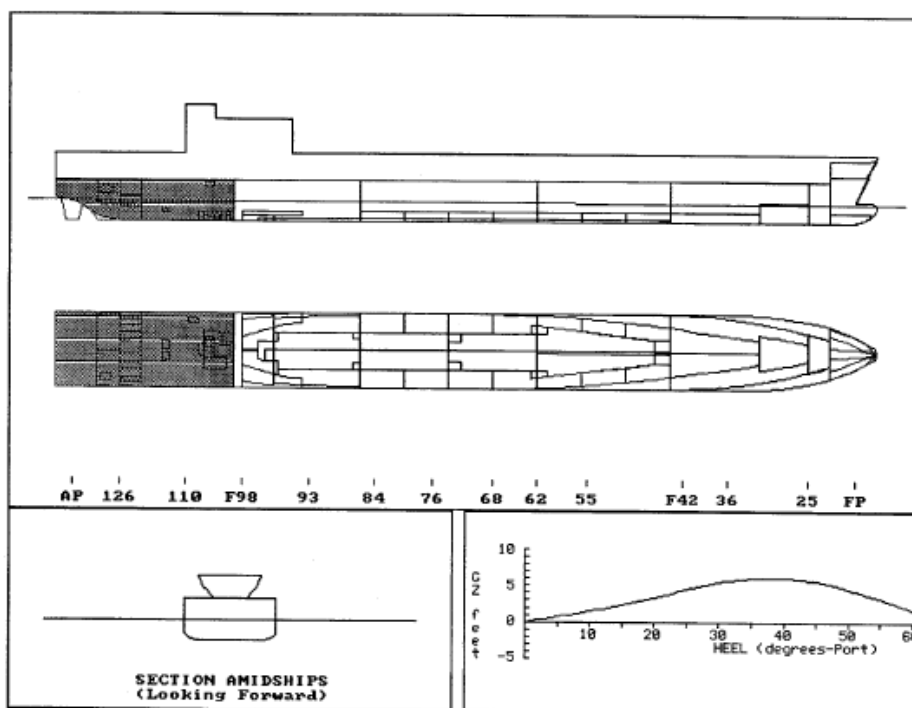
AP 126   110 F98   93   84   76   68 62 55   F42 36   25 FP

SECTION AMIDSHIPS
(Looking Forward)

SHEAR & LONGITUDINAL BENDING STRESS SUMMARY
Stresses in ksi

FAIRED LINES PLAN
(Based on Direct Calculation from Hull Offsets)
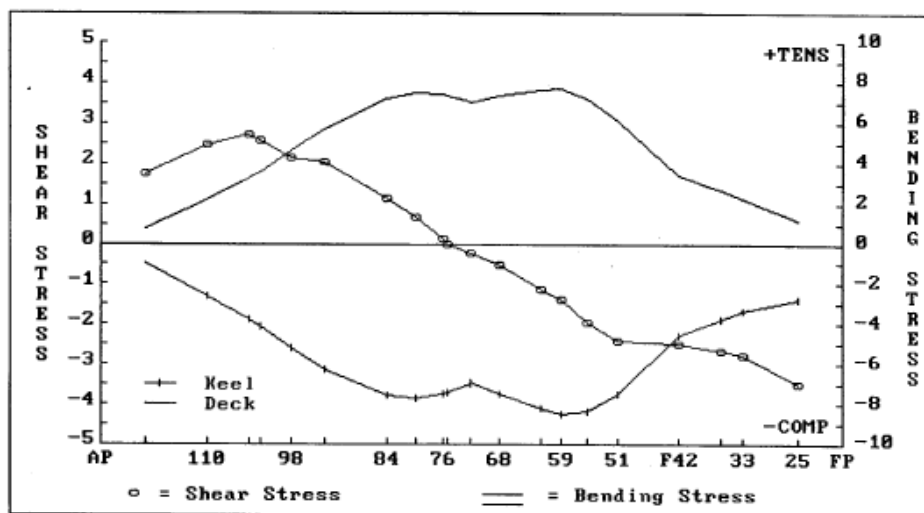
		SHEAR FORCES		BENDING MOMENTS		
	LOCATION	SHEAR	SHEAR STRESS	MOMENT	DK STRESS	KL STRESS
No.	ft-FP	LTons	ksi	ft-LTons	ksi	ksi
25	55.00A	-1,445	-3.51	49,824H	1.21	-2.75
33	121.00A	-2,671	-2.76	187,306H	2.25	-3.32
36	148.00A	-3,193	-2.67	266,758H	2.66	-3.75
F42	199.00A	-4,031	-2.48	452,011H	3.41	-4.57
51	274.00A	-3,536	-2.42	749,899H	6.14	-7.47
55	310.00A	-2,803	-1.97	865,169H	7.21	-8.35
59	343.00A	-2,011	-1.39	944,587H	7.70	-8.52
62	367.00A	-1,714	-1.13	988,120H	7.67	-8.23
68	418.00A	-865	-0.51	1,060,611H	7.38	-7.52
MS	452.50A	-409	-0.22	1,078,393H	7.01	-6.94
72	454.00A	-405	-0.22	1,078,988H	7.04	-6.97
Mx	480.86A	-0	-0.00	1,086,867H	7.37	-7.39
76	487.00A	187	0.11	1,086,318H	7.43	-7.48
80	520.00A	1,152	0.68	1,064,044H	7.50	-7.69
84	556.00A	1,930	1.15	1,008,171H	7.21	-7.55
93	631.00A	3,429	2.02	787,317H	5.69	-6.25
98	673.00A	3,695	2.15	642,959H	4.64	-5.23
F98	709.00A	4,427	2.55	497,355H	3.58	-4.14
104	724.00A	4,449	2.71	429,470H	3.26	-3.79
110	775.00A	3,254	2.46	235,499H	2.20	-2.63
126	851.00A	1,487	1.75	54,076H	0.76	-0.99

Maximum Shear Stress at 25:   -3.51 ksi
Maximum Deck Bending Stress at 59:   7.70 ksi
Maximum Keel Bending Stress at 59:   -8.52 ksi

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HOGGING FULL LOAD
AFT DAMAGE

FREE-FLOATING DAMAGED CONDITION

Damaged Compartments:

MACHY	LODT 8-103-4	ERWO 8-104-0	LOSM 8-104-1	LOSM 8-105-2	LORG 4-106-2
LORG 4-106-4	GTWD 8-107-0	BOLR CASCADE	FPST 7-112-1	LOPS 7-112-2	AFT
RGS 5-116-11	DP 6-116-1	SSDG 5-116-9	RGSL 5-116-7	ST 5-116-3	DTA 6-116-0
ST 5-116-1	SV 5-116-0	DP 6-116-4	POT 5-116-6	POT 5-116-8	DIS 5-116-10
GWT 5-126-1	APF 6-126-1	APF 6-126-2	SWHT 5-130-1		

	DISPLACEMENT LTons	DRAFT FWD ft	DRAFT AFT ft	TRIM ft	HEEL deg.	UPRIGHT GMt ft
INTACT	48,937	27.71	27.91	0.20A	0.1S	11.94
DAMAGED	46,207	28.28	17.62	10.66F	0.1P	7.61
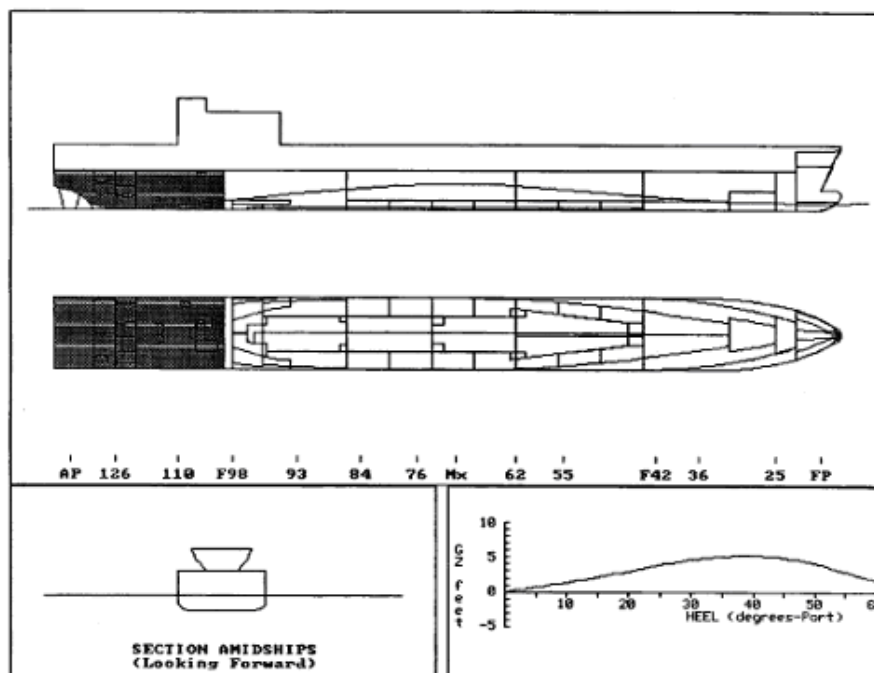
AP 126   110 F98   93   84   76 Mx   62   55   F42 36   25 FP

SECTION AMIDSHIPS
(Looking Forward)

150

RIGHTING ARM (GZ)
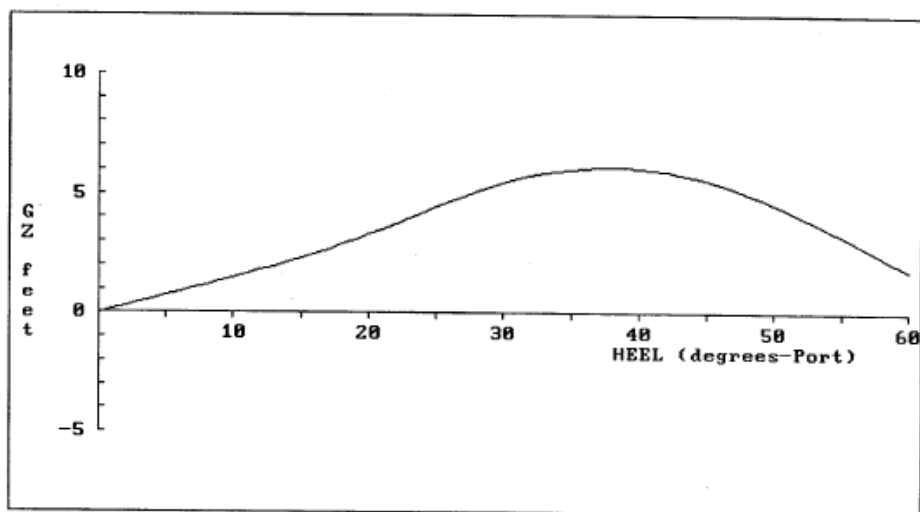
Stability Evaluation:

Static Heel Angle	0.1P deg	
Freeboard to Margin Line	62.62 ft	0.00 ft
Wind Heel Angle	1.4P deg	
Angle at Maximum GZ	37.9P deg	
Maximum GZ	6.11 ft	
Range of Positive GZ	>59.9 deg	
Gmt (upright damaged)	8.12 ft	

(Based on Direct Calculation from Hull Offsets)

Freeboards are calculated perpendicular to the water surface

SHEAR & LONGITUDINAL BENDING STRESS SUMMARY
Stresses in ksi

FAIRED LINES PLAN

Wave Height: 33.09 ft   Wave Position: 452.50A ft-FP
Wave Length: 905.00 ft

(Based on Direct Calculation from Hull Offsets)
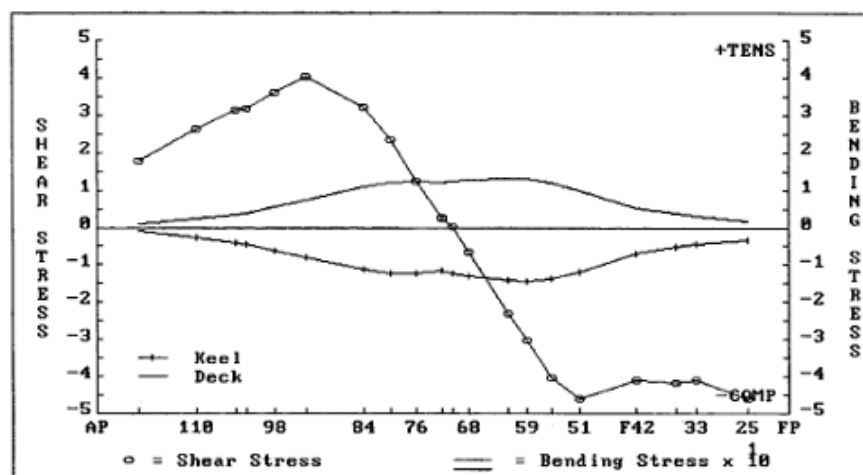
SHEAR & LONGITUDINAL BENDING STRESS SUMMARY
Stresses in ksi

FAIRED LINES PLAN

		SHEAR FORCES		BENDING MOMENTS		
	LOCATION	SHEAR	SHEAR STRESS	MOMENT	DK STRESS	KL STRESS
No.	ft-FP	LTons	ksi	ft-LTons	ksi	ksi
25	55.00A	-1,895	-4.60	64,218H	1.55	-3.56
33	121.00A	-3,979	-4.11	256,994H	3.09	-4.55
36	148.00A	-4,967	-4.16	377,985H	3.77	-5.31
F42	199.00A	-6,673	-4.11	676,430H	5.11	-6.83
51	274.00A	-6,746	-4.61	1,202,450H	9.85	-11.98
55	310.00A	-5,747	-4.04	1,430,198H	11.92	-13.80
59	343.00A	-4,398	-3.04	1,597,789H	13.03	-14.41
62	367.00A	-3,533	-2.32	1,692,094H	13.13	-14.09
68	418.00A	-1,153	-0.68	1,820,794H	12.67	-12.91
Mx	439.35A	1	0.00	1,831,078H	12.21	-12.22
MS	452.50A	442	0.24	1,827,694H	11.89	-11.77
72	454.00A	495	0.27	1,826,981H	11.91	-11.80
76	487.00A	2,122	1.22	1,788,420H	12.24	-12.32
80	520.00A	3,961	2.34	1,686,907H	11.90	-12.19
84	556.00A	5,393	3.20	1,516,197H	10.84	-11.35
93	631.00A	6,869	4.05	1,023,755H	7.40	-8.12
98	673.00A	6,177	3.59	752,604H	5.43	-6.13
F98	709.00A	5,545	3.19	540,738H	3.90	-4.50
104	724.00A	5,150	3.13	460,415H	3.50	-4.07
110	775.00A	3,490	2.63	240,599H	2.25	-2.69
126	851.00A	1,499	1.76	54,638H	0.77	-1.01

Maximum Shear Stress at 51:   -4.61 ksi

Maximum Deck Bending Stress at 62:   13.13 ksi

Maximum Keel Bending Stress at 59:   -14.41 ksi

SAGGING FULL LOAD
AFT DAMAGE

FREE-FLOATING DAMAGED CONDITION

Damaged Compartments:

MACHY	LODT 8-103-4	ERNO 8-104-0	LOSM 8-104-1	LOSM 8-105-2	LORG 4-106-2
LORG 4-106-4	GTWD 8-107-0	BOLR CASCADE	FPST 7-112-1	LOPS 7-112-2	AFT
RGS 5-116-11	DP 6-116-1	SSDG 5-116-9	RGSL 5-116-7	ST 5-116-3	DTA 6-116-0
ST 5-116-1	SV 5-116-0	DP 6-116-4	POT 5-116-6	POT 5-116-8	DIS 5-116-10
GWT 5-126-1	APF 6-126-1	APF 6-126-2	SWHT 5-130-1		

|	DISPLACEMENT LTons	DRAFT FWD ft	DRAFT AFT ft	TRIM ft	HEEL deg.	UPRIGHT GMt ft
INTACT	48,937	27.71	27.91	0.20A	0.1S	11.94
DAMAGED	64,300	26.83	45.00	18.17A	0.8S	10.40

SHEAR & LONGITUDINAL BENDING STRESS SUMMARY
Stresses in ksi

FAIRED LINES PLAN

Wave Height: 33.09 ft   Wave Position: 0.00   ft-FP
Wave Length: 905.00 ft

(Based on Direct Calculation from Hull Offsets)
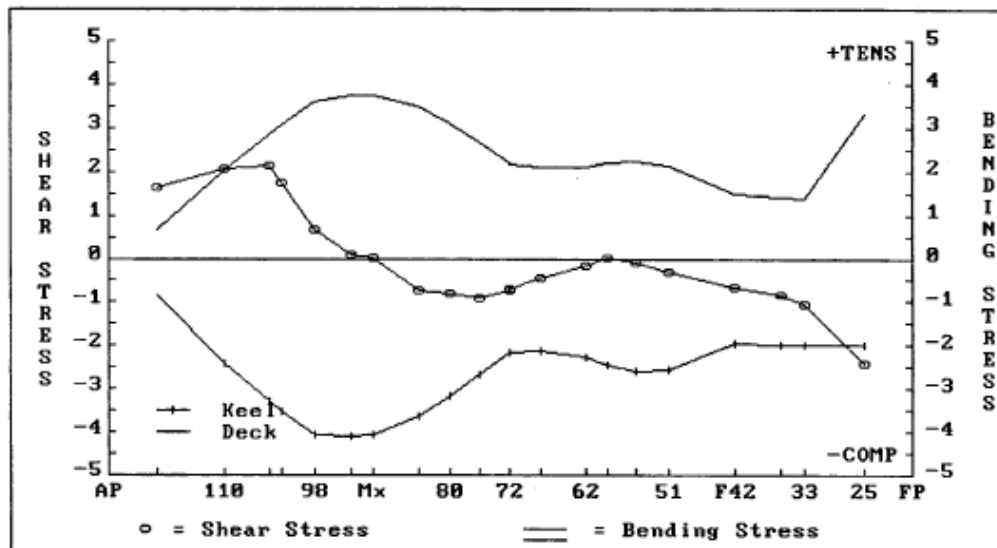
SHEAR & LONGITUDINAL BENDING STRESS SUMMARY
Stresses in ksi

FAIRED LINES PLAN

		SHEAR FORCES		BENDING MOMENTS		
	LOCATION	SHEAR	SHEAR STRESS	MOMENT	DK STRESS	KL STRESS
No.	ft-FP	LTons	ksi	ft-LTons	ksi	ksi
25	55.00A	-1,004	-2.44	40,050H	3.30	-1.99
33	121.00A	-1,032	-1.07	111,306H	1.37	-2.00
36	148.00A	-1,022	-0.86	139,264H	1.42	-1.98
F42	199.00A	-1,082	-0.67	192,134H	1.48	-1.97
51	274.00A	-442	-0.30	254,683H	2.12	-2.58
55	310.00A	-132	-0.09	264,607H	2.25	-2.59
59	343.00A	36	0.03	266,136H	2.21	-2.44
62	367.00A	-230	-0.15	267,283H	2.11	-2.26
68	418.00A	-767	-0.45	297,942H	2.11	-2.14
MS	452.50A	-1,287	-0.71	330,060H	2.18	-2.16
72	454.00A	-1,325	-0.73	332,001H	2.20	-2.18
76	487.00A	-1,608	-0.93	383,555H	2.66	-2.68
80	520.00A	-1,393	-0.82	433,638H	3.10	-3.18
84	556.00A	-1,208	-0.72	481,284H	3.49	-3.66
Mx	606.98A	1	0.00	514,027H	3.76	-4.06
93	631.00A	144	0.08	511,903H	3.76	-4.12
98	673.00A	1,148	0.67	492,315H	3.61	-4.06
F98	709.00A	3,052	1.76	418,819H	3.06	-3.53
104	724.00A	3,485	2.12	367,551H	2.84	-3.29
110	775.00A	2,719	2.05	212,632H	2.02	-2.41
126	851.00A	1,375	1.62	44,730H	0.65	-0.84

Maximum Shear Stress at 25:   -2.44 ksi
Maximum Deck Bending Stress at Mx: 3.76 ksi
Maximum Keel Bending Stress at 93:   -4.12 ksi

RIGHTING ARM (GZ)
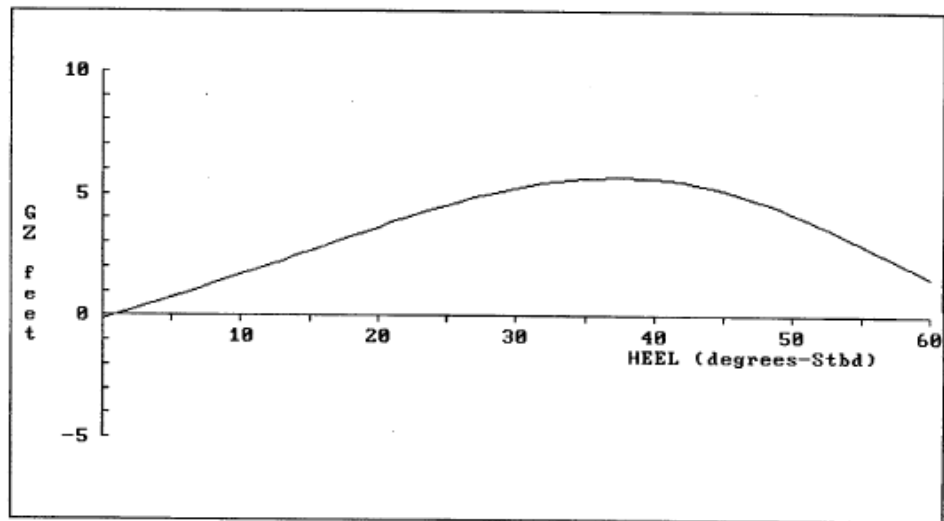
Stability Evaluation:

Static Heel Angle	0.8S deg	
Freeboard to Margin Line	46.88 ft	0.00 ft
Wind Heel Angle	1.6S deg	
Angle at Maximum GZ	37.5S deg	
Maximum GZ	5.68 ft	
Range of Positive GZ	>59.2 deg	
Gmt (upright damaged)	10.40 ft	

(Based on Direct Calculation from Hull Offsets)

Freeboards are calculated perpendicular to the water surface

STILLWATER MOC
FWD DAMAGE

FREE-FLOATING DAMAGED CONDITION

ITEM	WEIGHT LTons	KG ft-BL	LCG ft-FP	TCG ft-CL	FSmom ft-LTons
Light Ship	37,681	45.57	441.70A	0.65S	
Constant	0	0.00	452.50A	0.00	0
RoRo Cargo	0	0.00	452.50A	0.00	
Misc. Weight	1,032	43.27	464.10A	0.00	0
Fuel Oil	368	6.78	545.50A	0.02S	2,965
Diesel Oil	3,639	19.97	547.16A	0.65P	35,656
Lube Oil	90	47.08	837.03A	45.62S	77
Fresh Water	119	48.22	838.49A	38.66P	97
SW Ballast	3,216	14.90	644.76A	6.40P	9,930
Misc.	307	19.15	758.59A	6.57S	1,937
TOTALS	46,452	40.92	469.22A	0.07S	50,662

		INTACT	AFTER OUTFLOW	AS DAMAGED
Draft at F.P.	(ft)	26.87	----	25.86
Draft at A.P.	(ft)	26.52	----	29.25
Trim	(ft)	0.35F	----	3.39A
Draft at Fwd Marks	(ft)	26.86	----	25.93
Draft at Aft Marks	(ft)	26.53	----	29.16
Static Heel Angle	(deg)	0.4S	----	0.6P
Total Weight	(LT)	46,452	43,743	48,621
KG	(ft)	40.92	41.12	38.99
LCG	(ft-FP)	469.22A	446.08A	478.85A
TCG	(ft-CL)	0.07S	0.07P	0.13P
Buoyancy	(LT)	46,452	----	48,621
KB	(ft)	----	----	15.37
LCB	(ft-FP)	470.07A	----	478.93A
TCB	(ft-CL)	----	----	0.39P
KMt	(ft)	52.96	----	49.38
FSc	(ft)	1.09	----	0.87
GMt	(ft)	10.95	----	7.09
Shear Force	(LT)	----	----	4,519
Bending Moment	(ft-LT)	----	----	1,136,941H

AFTER OUTFLOW CONDITION:
  Displacement, KG, LCG, TCG include the effects of fluid outflow & flooding without free-communication.
AS DAMAGED CONDITION:
  Displacement, KG, LCG, TCG include the effects of the flooded water at the equilibrium trim/heel.
  Buoyancy, KB, LCB, TCB are for an intact hull at the equilibrium heel and drafts.
  KMt is for the damaged hull at the upright flooded drafts. GMt is the slope of the GZ curve at 0 degrees.
  F.S. correction accounts for the free surface of intact tanks and is corrected for outflow.

FREE-FLOATING DAMAGED CONDITION

Damaged Compartments:

FOCSLE	FPK 6--12-0	FB 8--11-0	HOLD 1	BOW THRUSTER	NO1 8-25-0
DP 8-32-1	DP 8-32-2				

	DISPLACEMENT LTons	DRAFT FWD ft	DRAFT AFT ft	TRIM ft	HEEL deg.	UPRIGHT GMt ft
INTACT	46,452	26.87	26.52	0.35F	0.4S	10.95
DAMAGED	52,197	38.93	20.55	18.38F	0.4S	10.32
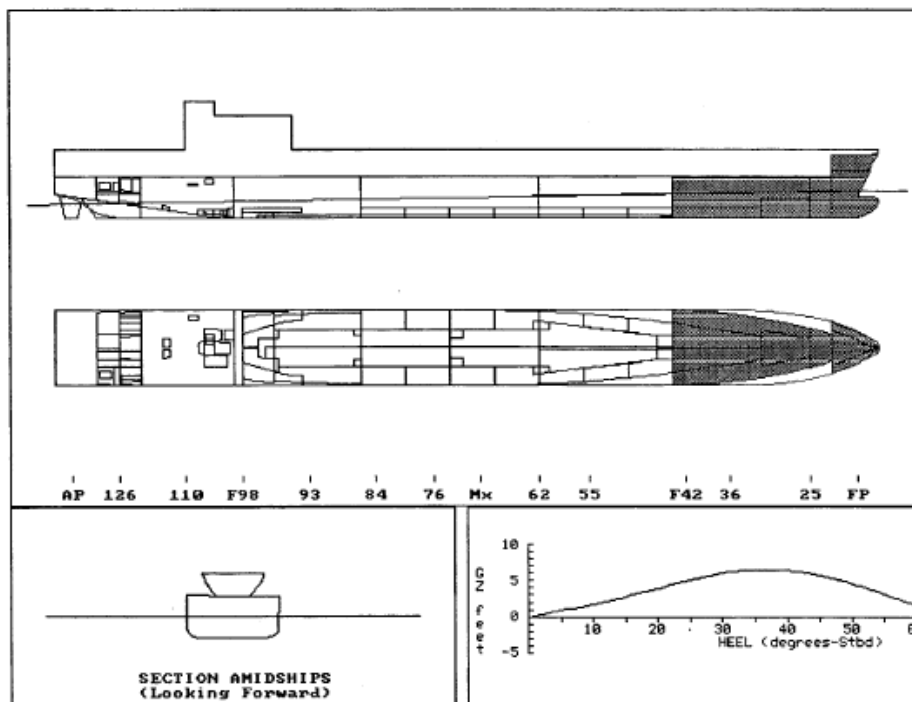
| AP | 126 | 110 | F98 | 93 | 84 | 76 | Mx | 62 | 55 | F42 | 36 | 25 | FP |

SECTION AMIDSHIPS
(Looking Forward)

SHEAR & LONGITUDINAL BENDING STRESS SUMMARY
Stresses in ksi

FAIRED LINES PLAN
(Based on Direct Calculation from Hull Offsets)
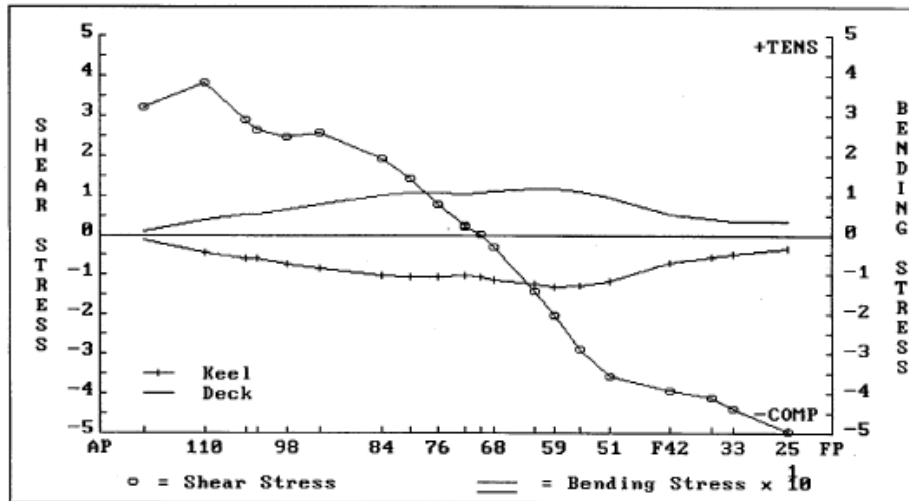
	LOCATION	SHEAR FORCES		BENDING MOMENTS		
		SHEAR	SHEAR STRESS	MOMENT	DK STRESS	KL STRESS
No.	ft-FP	LTons	ksi	ft-LTons	ksi	ksi
25	55.00A	-2,041	-4.95	67,269H	3.38	-3.30
33	121.00A	-4,237	-4.38	274,906H	3.34	-4.89
36	148.00A	-4,904	-4.11	398,330H	4.01	-5.62
F42	199.00A	-6,386	-3.93	685,001H	5.20	-6.96
51	274.00A	-5,206	-3.56	1,148,211H	9.47	-11.50
55	310.00A	-4,105	-2.88	1,316,839H	11.05	-12.78
59	343.00A	-2,928	-2.02	1,432,990H	11.76	-13.00
62	367.00A	-2,138	-1.41	1,493,252H	11.66	-12.51
68	418.00A	-533	-0.31	1,563,716H	10.95	-11.15
Mx	434.08A	0	0.00	1,567,683H	10.63	-10.67
MS	452.50A	381	0.21	1,563,599H	10.23	-10.13
72	454.00A	413	0.23	1,562,988H	10.25	-10.15
76	487.00A	1,355	0.78	1,535,791H	10.57	-10.64
80	520.00A	2,422	1.43	1,473,083H	10.45	-10.71
84	556.00A	3,228	1.92	1,370,710H	9.86	-10.32
93	631.00A	4,377	2.58	1,062,100H	7.72	-8.47
98	673.00A	4,232	2.46	886,057H	6.43	-7.25
F98	709.00A	4,579	2.63	727,452H	5.27	-6.08
104	724.00A	4,731	2.88	657,784H	5.03	-5.84
110	775.00A	5,074	3.83	404,969H	3.80	-4.54
126	851.00A	2,718	3.20	68,754H	0.98	-1.27

Maximum Shear Stress at 25:   -4.95 ksi
Maximum Deck Bending Stress at 59:   11.76 ksi
Maximum Keel Bending Stress at 59:   -13.00 ksi

RIGHTING ARM (GZ)
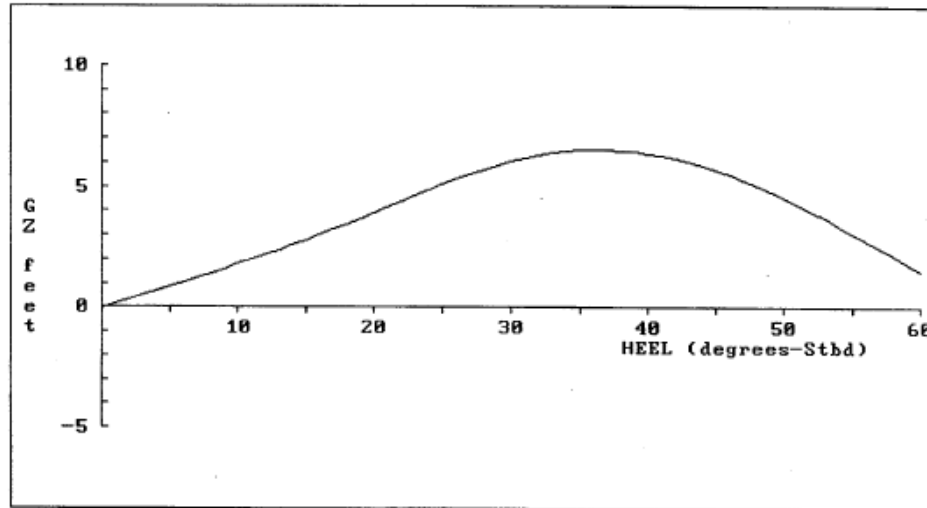
Stability Evaluation:

Static Heel Angle	0.4S	deg
Freeboard to Margin Line	53.59	ft	0.00 ft
Wind Heel Angle	1.4S	deg
Angle at Maximum GZ	36.4S	deg
Maximum GZ	6.53	ft
Range of Positive GZ	>59.6	deg
Gmt (upright damaged)	10.32	ft

(Based on Direct Calculation from Hull Offsets)

Freeboards are calculated perpendicular to the water surface

HOGGING MOC
FWD DAMAGE

FREE-FLOATING DAMAGED CONDITION

Damaged Compartments:

| FOCSLE | FPK 6--12-0 | FB 8--11-0 | HOLD 1 | BOW THRUSTER | NO1 8-25-0 |
| DP 8-32-1 | DP 8-32-2 | | | | |

	DISPLACEMENT LTons	DRAFT FWD ft	DRAFT AFT ft	TRIM ft	HEEL deg.	UPRIGHT GMt ft
INTACT	46,452	26.87	26.52	0.35F	0.4S	10.95
DAMAGED	47,412	24.14	23.02	1.12F	0.6S	6.85

SECTION AMIDSHIPS
(Looking Forward)

SHEAR & LONGITUDINAL BENDING STRESS SUMMARY
Stresses in ksi

FAIRED LINES PLAN

Wave Height: 33.09 ft   Wave Position: 452.50A ft-FP
Wave Length: 905.00 ft

(Based on Direct Calculation from Hull Offsets)
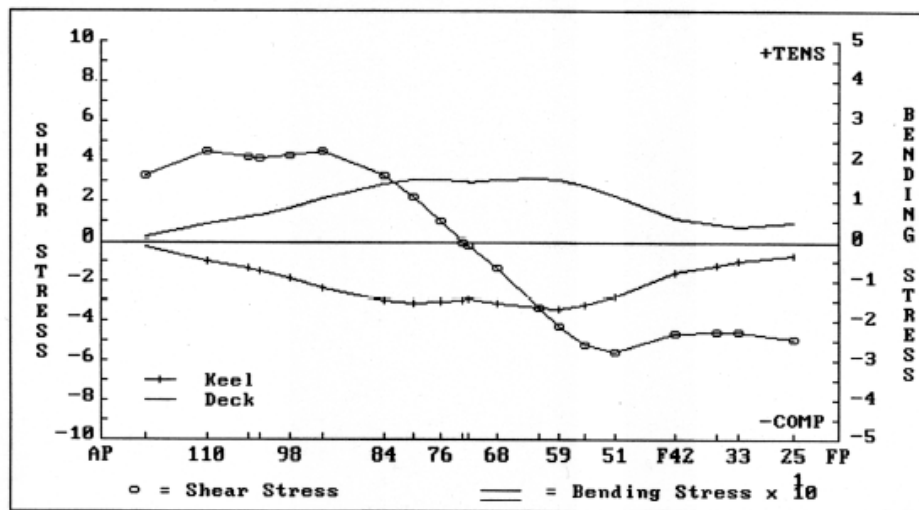
SHEAR & LONGITUDINAL BENDING STRESS SUMMARY
Stresses in ksi

FAIRED LINES PLAN

		SHEAR FORCES		BENDING MOMENTS		
	LOCATION	SHEAR	SHEAR STRESS	MOMENT	DK STRESS	KL STRESS
No.	ft-FP	LTons	ksi	ft-LTons	ksi	ksi
25	55.00A	-2,239	-5.43	66,662H	2.64	-3.25
33	121.00A	-3,323	-3.44	255,952H	3.09	-4.54
36	148.00A	-3,337	-2.79	345,744H	3.46	-4.87
F42	199.00A	-4,175	-2.57	531,901H	4.03	-5.39
51	274.00A	-1,666	-1.14	783,195H	6.44	-7.82
55	310.00A	-381	-0.27	819,038H	6.85	-7.92
Mx	322.30A	1	0.00	821,435H	6.81	-7.74
59	343.00A	600	0.41	815,154H	6.67	-7.37
62	367.00A	1,061	0.70	794,554H	6.18	-6.64
68	418.00A	1,553	0.91	727,457H	5.08	-5.17
MS	452.50A	1,502	0.82	672,501H	4.39	-4.34
72	454.00A	1,488	0.82	670,240H	4.38	-4.34
76	487.00A	1,427	0.83	623,174H	4.28	-4.30
80	520.00A	1,487	0.88	575,094H	4.07	-4.17
84	556.00A	1,272	0.76	525,520H	3.77	-3.94
93	631.00A	888	0.52	427,520H	3.10	-3.40
98	673.00A	415	0.24	406,464H	2.94	-3.32
F98	709.00A	853	0.49	384,706H	2.78	-3.21
104	724.00A	1,150	0.70	369,931H	2.82	-3.27
110	775.00A	2,443	1.84	278,494H	2.61	-3.12
126	851.00A	2,210	2.60	60,571H	0.86	-1.12

```
Maximum Shear Stress at 25:             -5.43 ksi
Maximum Deck Bending Stress at 55:       6.85 ksi
Maximum Keel Bending Stress at 55:      -7.92 ksi
```

RIGHTING ARM (GZ)
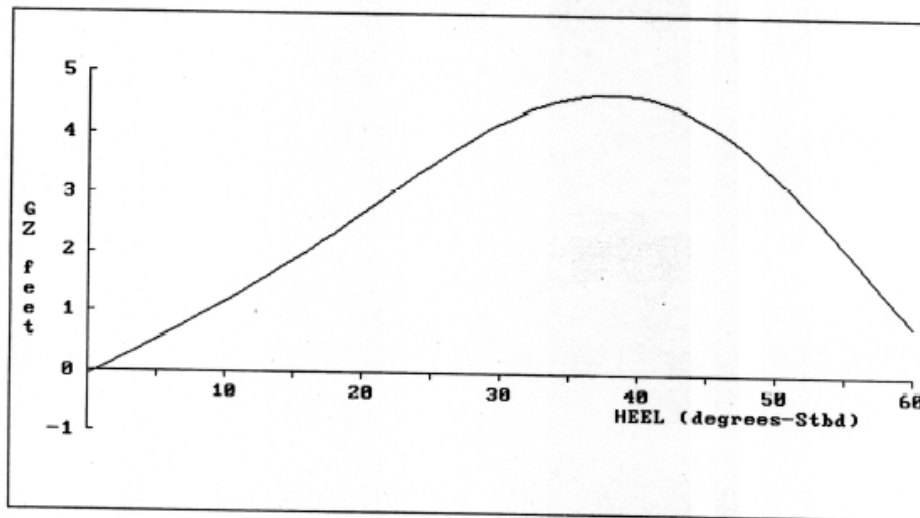
Stability Evaluation:

Static Heel Angle	0.6S	deg	
Freeboard to Margin Line	68.52	ft	0.00 ft
Wind Heel Angle	2.5S	deg	
Angle at Maximum GZ	38.0S	deg	
Maximum GZ	4.67	ft	
Range of Positive GZ	>59.4	deg	
Gmt (upright damaged)	6.85	ft	

(Based on Direct Calculation from Hull Offsets)

Freeboards are calculated perpendicular to the water surface

**SAGGING MOC
FWD DAMAGE**

FREE-FLOATING DAMAGED CONDITION

Damaged Compartments:

FOCSLE	FPK 6--12-0	FB 8--11-0	HOLD 1	BOW THRUSTER	NO1 8-25-0
DP 8-32-1	DP 8-32-2				

	DISPLACEMENT LTons	DRAFT FWD ft	DRAFT AFT ft	TRIM ft	HEEL deg.	UPRIGHT GMt ft
INTACT	46,452	26.87	26.52	0.35F	0.4S	10.95
DAMAGED	58,038	55.99	16.95	39.04F	0.2S	17.42
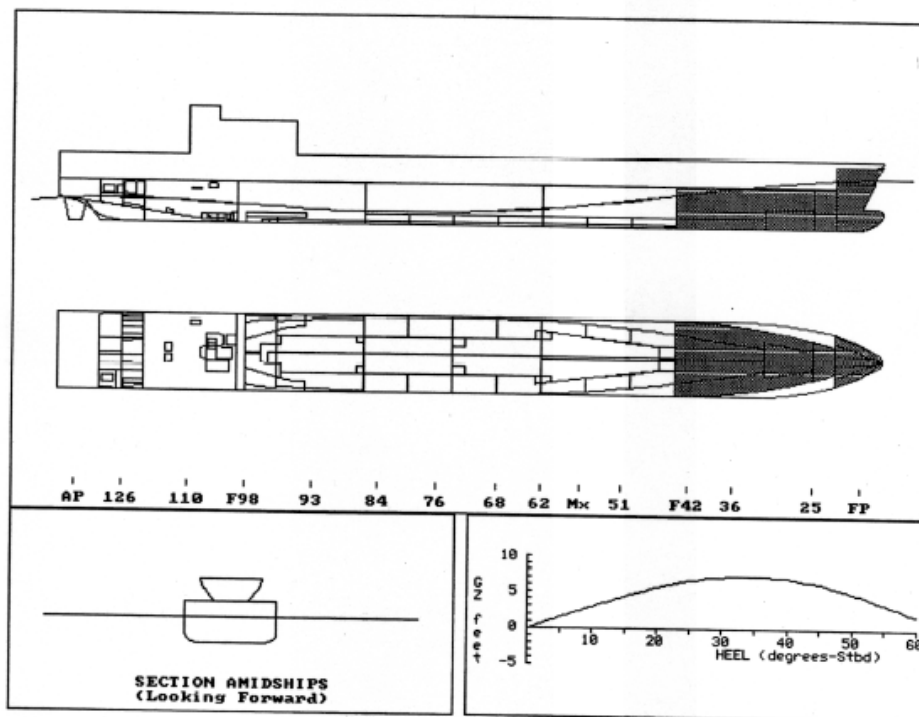
AP 126 110 F98 93 84 76 68 62 Mx 51 F42 36 25 FP

SECTION AMIDSHIPS
**(Looking Forward)**

SHEAR & LONGITUDINAL BENDING STRESS SUMMARY
Stresses in ksi

FAIRED LINES PLAN

Wave Height: 33.09 ft   Wave Position: 0.00   ft-FP
Wave Length: 905.00 ft

(Based on Direct Calculation from Hull Offsets)

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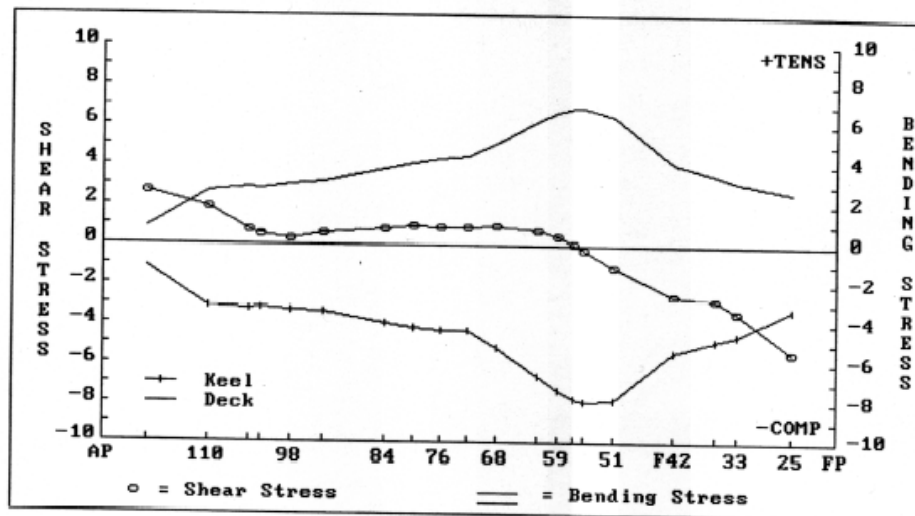
RIGHTING ARM (GZ)
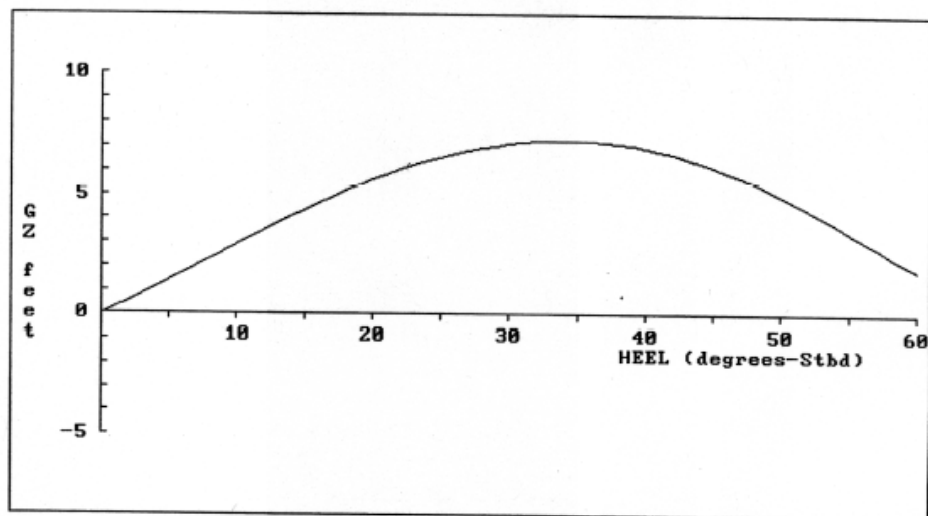
Stability Evaluation:

Static Heel Angle	0.2S	deg	
Freeboard to Margin Line	35.97	ft	0.00 ft
Wind Heel Angle	0.6S	deg	
Angle at Maximum GZ	34.1S	deg	
Maximum GZ	7.26	ft	
Range of Positive GZ	>59.8	deg	
Gmt (upright damaged)	17.42	ft	

(Based on Direct Calculation from Hull Offsets)
Freeboards are calculated perpendicular to the water surface

FREE-FLOATING DAMAGED CONDITION

ITEM	WEIGHT LTons	KG ft-BL	LCG ft-FP	TCG ft-CL	FSmom ft-LTons
Light Ship	37,681	45.57	441.70A	0.65S	
Constant	0	0.00	452.50A	0.00	0
RoRo Cargo	0	0.00	452.50A	0.00	
Misc. Weight	1,032	43.27	464.10A	0.00	0
Fuel Oil	368	6.78	545.50A	0.02S	2,965
Diesel Oil	3,639	19.97	547.16A	0.65P	35,656
Lube Oil	90	47.08	837.03A	45.62S	77
Fresh Water	119	48.22	838.49A	38.66P	97
SW Ballast	3,216	14.90	644.76A	6.40P	9,930
Misc.	307	19.15	758.59A	6.57S	1,937
TOTALS	46,452	40.92	469.22A	0.07S	50,662

		INTACT	AFTER OUTFLOW	AS DAMAGED
Draft at F.P.	(ft)	26.87	----	38.93
Draft at A.P.	(ft)	26.52	----	20.55
Trim	(ft)	0.35F	----	18.38F
Draft at Fwd Marks	(ft)	26.86	----	38.52
Draft at Aft Marks	(ft)	26.53	----	21.06
Static Heel Angle	(deg)	0.4S	----	0.4S
Total Weight	(LT)	46,452	45,579	52,197
KG	(ft)	40.92	41.52	38.90
LCG	(ft-FP)	469.22A	474.96A	431.34A
TCG	(ft-CL)	0.07S	0.07S	0.07S
Buoyancy	(LT)	46,452	----	52,197
KB	(ft)	----	----	16.66
LCB	(ft-FP)	470.07A	----	430.89A
TCB	(ft-CL)	----	----	0.22S
KMt	(ft)	52.96	----	53.06
FSc	(ft)	1.09	----	0.94
GMt	(ft)	10.95	----	10.32
Shear Force	(LT)	----	----	-6,386
Bending Moment	(ft-LT)	----	----	1,567,683H

AFTER OUTFLOW CONDITION:

  Displacement, KG, LCG, TCG include the effects of fluid outflow & flooding without free-communication.

AS DAMAGED CONDITION:

  Displacement, KG, LCG, TCG include the effects of the flooded water at the equilibrium trim/heel.

  Buoyancy, KB, LCB, TCB are for an intact hull at the equilibrium heel and drafts.

  KMt is for the damaged hull at the upright flooded drafts. GMt is the slope of the GZ curve at 0 degrees.

  F.S. correction accounts for the free surface of intact tanks and is corrected for outflow.

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STILLWATER MOC
MD DAMAGE

FREE-FLOATING DAMAGED CONDITION

Damaged Compartments:

HOLD 2	W2A 8-44-01	FD 0-44-1	W2A 8-44-4	FB 8-44-2	W2B 8-50-1
W2B 8-50-2	W2C 8-56-1	W2C 8-56-2	HOLD 3	W3A 8-62-1	DB3F 8-62-0
DB3F 8-62-2	W3A 8-62-4	W3B 8-68-1	W3B 8-68-2	W3C 8-74-1	DB3A 8-74-0
DB3A 8-74-2	W3C 8-74-4	W3D 8-80-1	W3D 8-80-2		

	DISPLACEMENT LTons	DRAFT FWD ft	DRAFT AFT ft	TRIM ft	HEEL deg.	UPRIGHT GMt ft
INTACT	46,452	26.87	26.52	0.35F	0.4S	10.95
DAMAGED	74,620	49.28	29.92	19.36F	2.5S	9.09
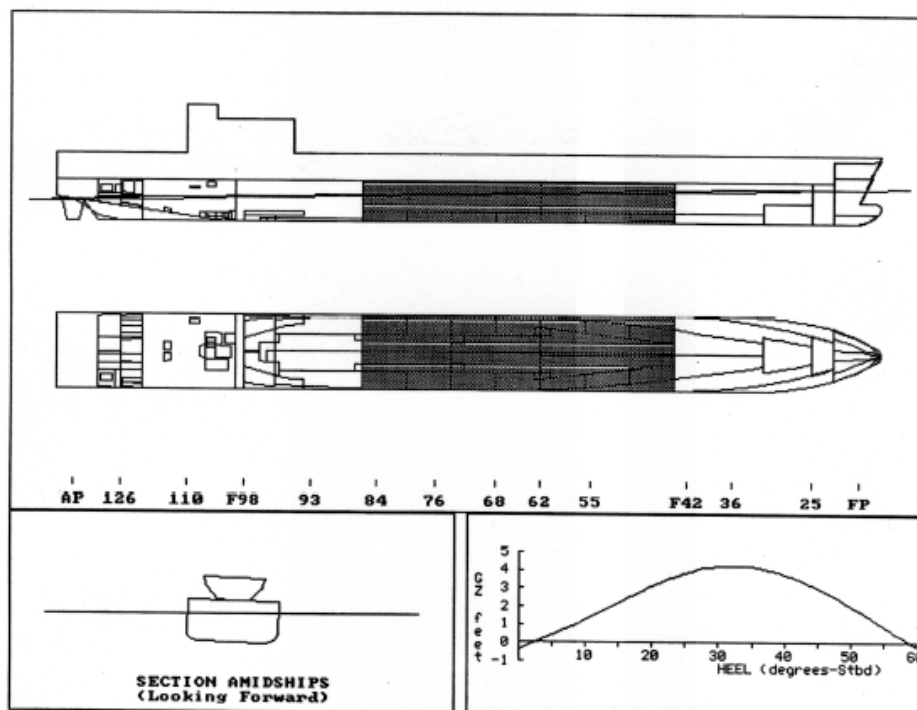
AP 126 110 F98 93 84 76 68 62 55 F42 36 25 FP

SECTION AMIDSHIPS
(Looking Forward)

HEEL (degrees-Stbd)

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SHEAR & LONGITUDINAL BENDING STRESS SUMMARY
Stresses in ksi

FAIRED LINES PLAN
(Based on Direct Calculation from Hull Offsets)

o = Shear Stress   ═══ = Bending Stress
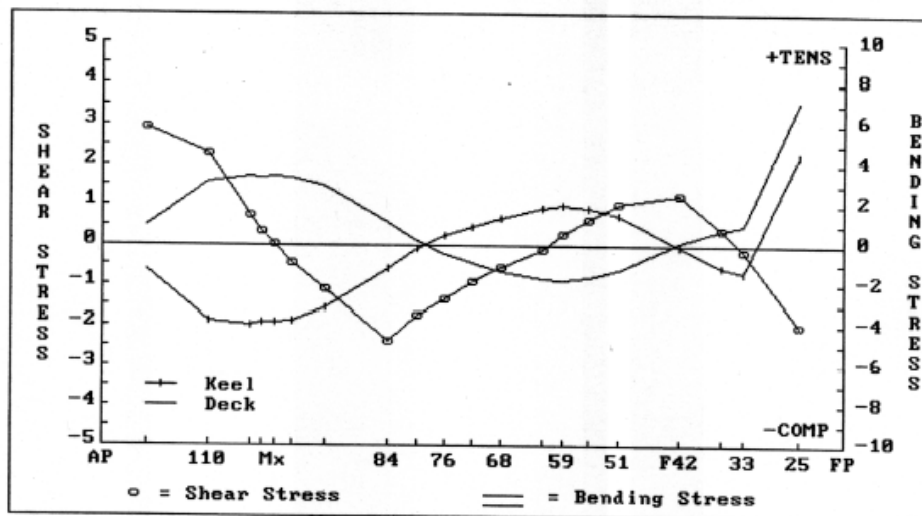
		SHEAR FORCES			BENDING MOMENTS	
	LOCATION	SHEAR	SHEAR STRESS	MOMENT	DK STRESS	KL STRESS
No.	ft-FP	LTons	ksi	ft-LTons	ksi	ksi
25	55.00A	-818	-1.98	36,132H	7.12	4.51
33	121.00A	-161	-0.17	76,702H	1.00	-1.42
36	148.00A	436	0.36	73,620H	0.78	-1.08
F42	199.00A	2,035	1.25	13,120H	0.10	-0.14
51	274.00A	1,478	1.01	141,187S	-1.22	1.47
55	310.00A	894	0.63	183,262S	-1.62	1.06
59	343.00A	370	0.26	204,520S	-1.76	1.94
62	367.00A	-168	-0.11	207,657S	-1.70	1.82
68	418.00A	-944	-0.56	177,098S	-1.29	1.32
MS	452.50A	-1,636	-0.90	135,328S	-0.92	0.91
72	454.00A	-1,674	-0.92	132,862S	-0.91	0.90
76	487.00A	-2,346	-1.35	65,153S	-0.47	0.47
80	520.00A	-2,963	-1.75	22,042H	0.16	-0.17
84	556.00A	-4,005	-2.38	146,767H	1.10	-1.15
93	631.00A	-1,865	-1.10	379,719H	2.88	-3.15
98	673.00A	-785	-0.46	440,087H	3.33	-3.73
Mx	693.17A	3	0.00	448,130H	3.38	-3.85
F98	709.00A	609	0.35	443,238H	3.34	-3.84
104	724.00A	1,195	0.73	429,873H	3.42	-3.95
110	775.00A	3,008	2.27	319,890H	3.14	-3.73
126	851.00A	2,468	2.91	64,473H	0.98	-1.26

Maximum Shear Stress at 126:   2.91 ksi
Maximum Deck Bending Stress at 25:   7.12 ksi
Maximum Keel Bending Stress at 25:   4.51 ksi

RIGHTING ARM (GZ)
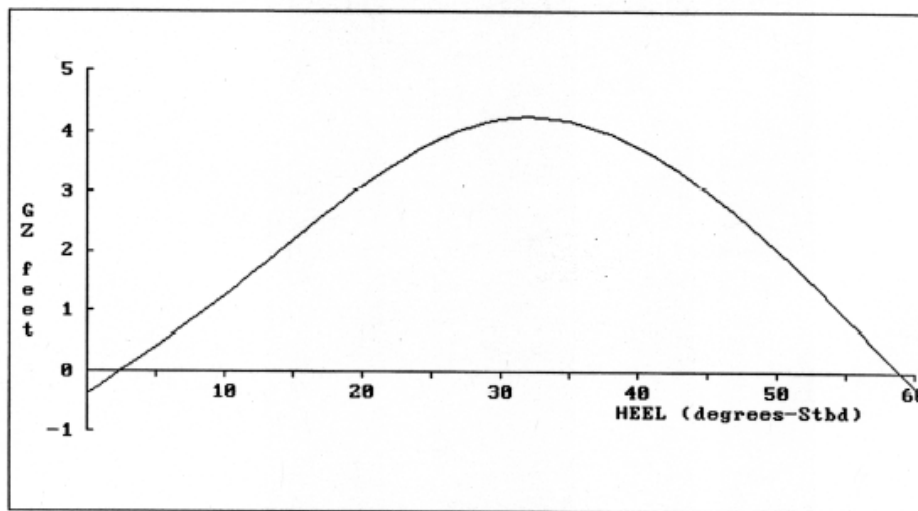
Stability Evaluation:

Static Heel Angle	2.5S deg	
Freeboard to Margin Line	42.90 ft	0.00 ft
Wind Heel Angle	3.1S deg	
Angle at Maximum GZ	32.1S deg	
Maximum GZ	4.25 ft	
Range of Positive GZ	56.5 deg	
Gmt (upright damaged)	9.09 ft	

(Based on Direct Calculation from Hull Offsets)

Freeboards are calculated perpendicular to the water surface

HOGGING MOC
MD DAMAGE

FREE-FLOATING DAMAGED CONDITION

Damaged Compartments:

HOLD 3	W2A 0-44-01	FB 8-44-1	W2A 8-44-4	FB 8-44-2	W2B 8-50-1
W2B 8-50-2	W2C 8-56-1	W2C 8-56-2	HOLD 3	W3A 8-62-1	DB3F 8-62-0
DB3F 8-62-2	W3A 8-62-4	W3B 8-68-1	W3B 8-68-2	W3C 8-74-1	DB3A 8-74-0
DB3A 8-74-2	W3C 8-74-4	W3D 8-80-1	W3D 8-80-2		

	DISPLACEMENT LTons	DRAFT FWD ft	DRAFT AFT ft	TRIM ft	HEEL deg.	UPRIGHT GMt ft
INTACT	46,452	26.87	26.52	0.35F	0.4S	10.95
DAMAGED	84,321	51.84	32.07	19.77F	4.1S	6.19

SECTION AMIDSHIPS
(Looking Forward)

SHEAR & LONGITUDINAL BENDING STRESS SUMMARY
Stresses in ksi

FAIRED LINES PLAN

Wave Height: 33.09 ft   Wave Position: 452.50A ft-FP
Wave Length: 905.00 ft

(Based on Direct Calculation from Hull Offsets)
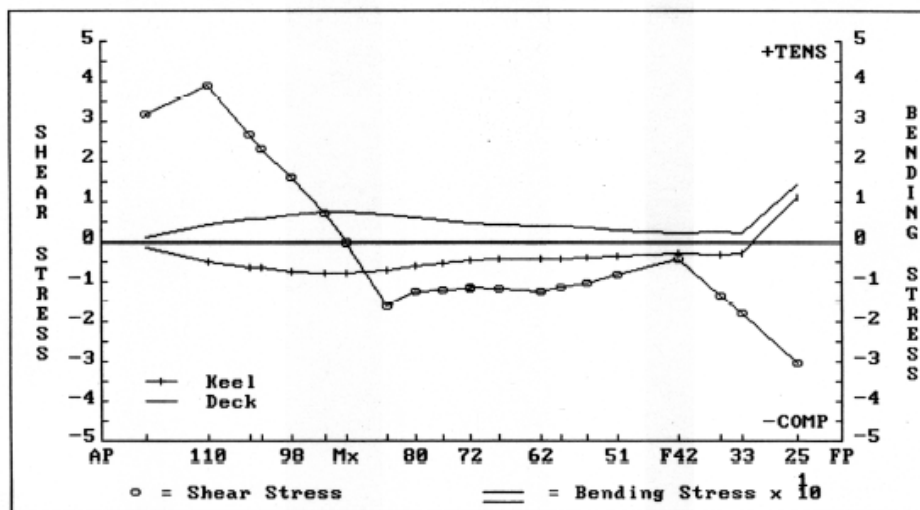
SHEAR & LONGITUDINAL BENDING STRESS SUMMARY
Stresses in ksi

FAIRED LINES PLAN

		SHEAR FORCES		BENDING MOMENTS		
	LOCATION	SHEAR	SHEAR STRESS	MOMENT	DK STRESS	KL STRESS
No.	ft-FP	LTons	ksi	ft-LTons	ksi	ksi
25	55.00A	-1,241	-3.01	44,765H	14.07	10.84
33	121.00A	-1,724	-1.78	148,795H	2.03	-2.84
36	148.00A	-1,622	-1.36	194,699H	2.17	-2.94
F42	199.00A	-666	-0.41	257,835H	2.14	-2.79
51	274.00A	-1,164	-0.80	309,241H	2.78	-3.33
55	310.00A	-1,464	-1.03	358,137H	3.28	-3.74
59	343.00A	-1,625	-1.12	408,514H	3.64	-4.00
62	367.00A	-1,873	-1.23	449,696H	3.81	-4.06
68	418.00A	-2,001	-1.18	553,149H	4.17	-4.24
MS	452.50A	-2,075	-1.14	620,212H	4.36	-4.32
72	454.00A	-2,084	-1.15	623,339H	4.39	-4.35
76	487.00A	-2,105	-1.21	695,425H	5.15	-5.18
80	520.00A	-2,122	-1.25	762,916H	5.83	-5.96
84	556.00A	-2,711	-1.61	848,289H	6.56	-6.85
Mx	604.91A	-25	-0.02	939,985H	7.32	-7.86
93	631.00A	1,200	0.71	921,599H	7.21	-7.85
98	673.00A	2,717	1.58	841,896H	6.56	-7.34
F98	709.00A	4,002	2.30	719,610H	5.60	-6.40
104	724.00A	4,420	2.69	656,532H	5.39	-6.20
110	775.00A	5,173	3.90	406,074H	4.13	-4.87
126	851.00A	2,692	3.17	66,950H	1.07	-1.35

Maximum Shear Stress at 110:   3.90 ksi
Maximum Deck Bending Stress at 25: 14.07 ksi
Maximum Keel Bending Stress at 25: 10.84 ksi

RIGHTING ARM (GZ)
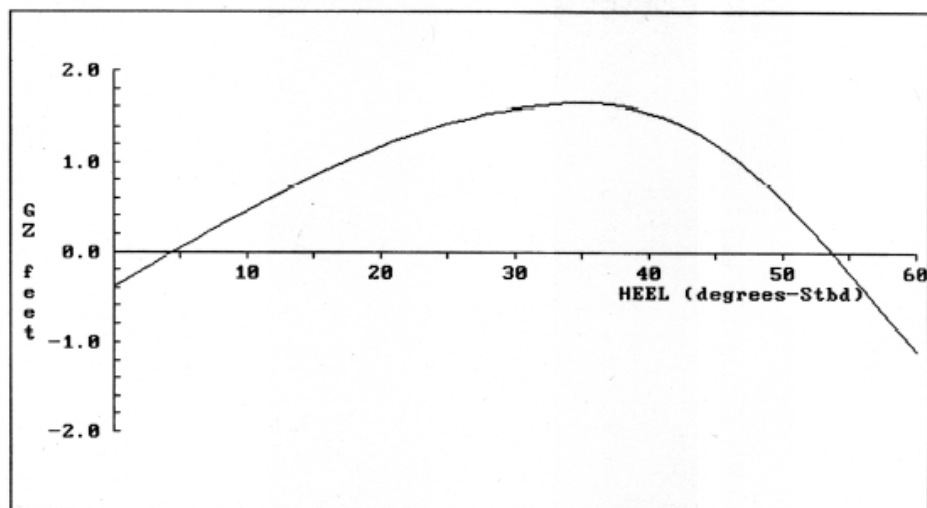
Stability Evaluation:

Static Heel Angle	4.1S	deg
Freeboard to Margin Line	39.38	ft	0.00 ft
Wind Heel Angle	5.2S	deg
Angle at Maximum GZ	34.8S	deg
Maximum GZ	1.65	ft
Range of Positive GZ	49.5	deg
Gmt (upright damaged)	6.19	ft

(Based on Direct Calculation from Hull Offsets)

Freeboards are calculated perpendicular to the water surface

SAGGING MOC
MD DAMAGE

FREE-FLOATING DAMAGED CONDITION

Damaged Compartments:

HOLD 2	W2A 8-44-01	FD 0-44-1	W2A 8-44-4	FB 8-44-2	W2B 8-50-1
W2B 8-50-2	W2C 8-56-1	W2C 8-56-2	HOLD 3	W3A 8-62-1	DB3F 8-62-0
DB3F 8-62-2	W3A 8-62-4	W3B 8-68-1	W3B 8-68-2	W3C 8-74-1	DB3A 8-74-0
DB3A 8-74-2	W3C 8-74-4	W3D 8-80-1	W3D 8-80-2		

	DISPLACEMENT LTons	DRAFT FWD ft	DRAFT AFT ft	TRIM ft	HEEL deg.	UPRIGHT GMt ft
INTACT	46,452	26.87	26.52	0.35F	0.4S	10.95
DAMAGED	64,620	50.48	26.11	24.36F	1.5S	15.22

SECTION AMIDSHIPS
(Looking Forward)

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SHEAR & LONGITUDINAL BENDING STRESS SUMMARY
Stresses in ksi

FAIRED LINES PLAN

Wave Height: 33.09 ft   Wave Position: 0.00   ft-FP
Wave Length: 905.00 ft

(Based on Direct Calculation from Hull Offsets)
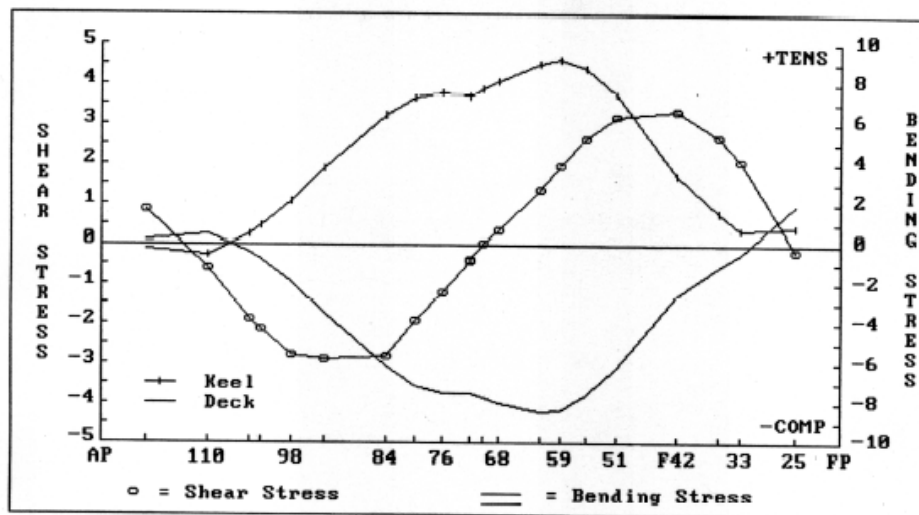
SHEAR & LONGITUDINAL BENDING STRESS SUMMARY
### Stresses in ksi

FAIRED LINES PLAN

		SHEAR FORCES		BENDING MOMENTS		
No.	LOCATION ft-FP	SHEAR LTons	SHEAR STRESS ksi	MOMENT ft-LTons	DK STRESS ksi	KL STRESS ksi
25	55.00A	=69	=0.17	14,825H	1.89	0.81
33	121.00A	1,998	2.07	36,686S	-0.46	0.67
36	148.00A	3,187	2.67	106,375S	-1.10	1.53
F42	199.00A	5.389	3.32	325.934S	-2.54	3.38
51	274.00A	4,655	3.18	729,714S	-6.18	7.47
55	310.00A	3,743	2.63	881,458S	-7.59	8.75
59	343.00A	2,844	1.96	990,058S	-8.34	9.19
62	367.00A	2,021	1.33	1,048,967S	-8.40	8.99
68	418.00A	581	0.34	1,115,442S	-7.99	8.13
Mx	436.77A	0	0.00	1,120,818S	-7.73	7.74
MS	452.50A	-714	-0.39	1,115,252S	-7.46	7.38
72	454.00A	-779	-0.43	1,114,151S	-7.47	7.40
76	487.00A	-2,057	-1.19	1,066,769S	-7.51	7.55
80	520.00A	-3,238	-1.91	979,272S	-7.10	7.28
84	556.00A	-4,766	-2.83	834,960S	-6.14	6.42
93	631.00A	-4,915	-2.90	466,346S	-3.47	3.80
98	673.00A	-4,748	-2.76	256,802S	-1.91	2.14
F98	709.00A	-3,692	-2.12	103,611S	-0.77	0.88
104	724.00A	-3,120	-1.90	52,255S	-0.41	0.47
110	775.00A	-807	-0.61	48,603H	0.47	-0.56
126	851.00A	709	0.84	12,762H	0.19	-0.24

```
Maximum Shear Stress at F42:           3.32 ksi
Maximum Deck Bending Stress at 62:    -8.40 ksi
Maximum Keel Bending Stress at 59:     9.19 ksi
```

RIGHTING ARM (GZ)
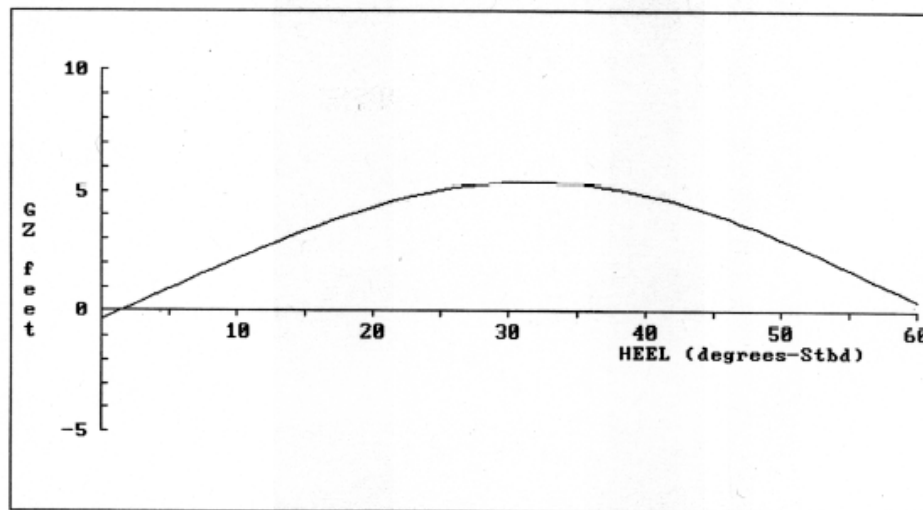
Stability Evaluation:

Static Heel Angle	1.5S	deg
Freeboard to Margin Line	41.86	ft	0.00 ft
Wind Heel Angle	1.9S	deg
Angle at Maximum GZ	31.7S	deg
Maximum GZ	5.40	ft
Range of Positive GZ	>58.5	deg
Gmt (upright damaged)	15.22	ft

(Based on Direct Calculation from Hull Offsets)

Freeboards are calculated perpendicular to the water surface

FREE-FLOATING DAMAGED CONDITION

ITEM	WEIGHT LTons	KG ft-BL	LCG ft-FP	TCG ft-CL	FSmom ft-LTons
Light Ship	37,681	45.57	441.70A	0.65S	
Constant	0	0.00	452.50A	0.00	0
RoRo Cargo	0	0.00	452.50A	0.00	
Misc. Weight	1,032	43.27	464.10A	0.00	0
Fuel Oil	368	6.78	545.50A	0.02S	2,965
Diesel Oil	3,639	19.97	547.16A	0.65P	35,656
Lube Oil	90	47.08	837.03A	45.62S	77
Fresh Water	119	48.22	838.49A	38.66P	97
SW Ballast	3,216	14.90	644.76A	6.40P	9,930
Misc.	307	19.15	758.59A	6.57S	1,937
TOTALS	46,452	40.92	469.22A	0.07S	50,662

		INTACT	AFTER OUTFLOW	AS DAMAGED
Draft at F.P.	(ft)	26.87	----	49.28
Draft at A.P.	(ft)	26.52	----	29.92
Trim	(ft)	0.35F	----	19.36F
Draft at Fwd Marks	(ft)	26.86	----	48.85
Draft at Aft Marks	(ft)	26.53	----	30.46
Static Heel Angle	(deg)	0.4S	----	2.5S
Total Weight	(LT)	46,452	44,307	74,620
KG	(ft)	40.92	42.57	33.61
LCG	(ft-FP)	469.22A	471.06A	440.71A
TCG	(ft-CL)	0.07S	0.44S	0.63S
Buoyancy	(LT)	46,452	----	74,620
KB	(ft)	----	----	22.06
LCB	(ft-FP)	470.07A	----	440.47A
TCB	(ft-CL)	----	----	1.15S
KMt	(ft)	52.96	----	52.80
FSc	(ft)	1.09	----	0.87
GMt	(ft)	10.95	----	9.09
Shear Force	(LT)	----	----	=4,005
Bending Moment	(ft-LT)	----	----	448,130H

AFTER OUTFLOW CONDITION:

  Displacement, KG, LCG, TCG include the effects of fluid outflow & flooding without free-communication.

AS DAMAGED CONDITION:

  Displacement, KG, LCG, TCG include the effects of the flooded water at the equilibrium trim/heel.

  Buoyancy, KB, LCB, TCB are for an intact hull at the equilibrium heel and drafts.

  KMt is for the damaged hull at the upright flooded drafts. GMt is the slope of the GZ curve at 0 degrees.

  F.S. correction accounts for the free surface of intact tanks and is corrected for outflow.

STILLWATER MOC
AFT DAMAGE

FREE-FLOATING DAMAGED CONDITION

Damaged Compartments:

MACHY	LODT 8-103-4	ERWO 8-104-0	LOSM 8-104-1	LOSM 0-105-2	LORG 4-106-2
LORG 4-106-4	GTWD 8-107-0	BOLR CASCADE	FPST 7-112-1	LOPS 7-112-2	AFT
RGS 5-116-11	DP 6-116-1	SSDG 5-116-9	RGSL 5-116-7	ST 5-116-3	DTA 6-116-0
ST 5-116-1	SV 5-116-0	DP 6-116-4	POT 5-116-6	POT 5-116-8	DIS 5-116-10
GWT 5-126-1	APF 6-126-1	APF 6-126-2			

	DISPLACEMENT LTons	DRAFT FWD ft	DRAFT AFT ft	TRIM ft	HEEL deg.	UPRIGHT GMt ft
INTACT	46,452	26.87	26.52	0.35F	0.4S	10.95
DAMAGED	48,621	25.86	29.25	3.39A	0.6P	7.09
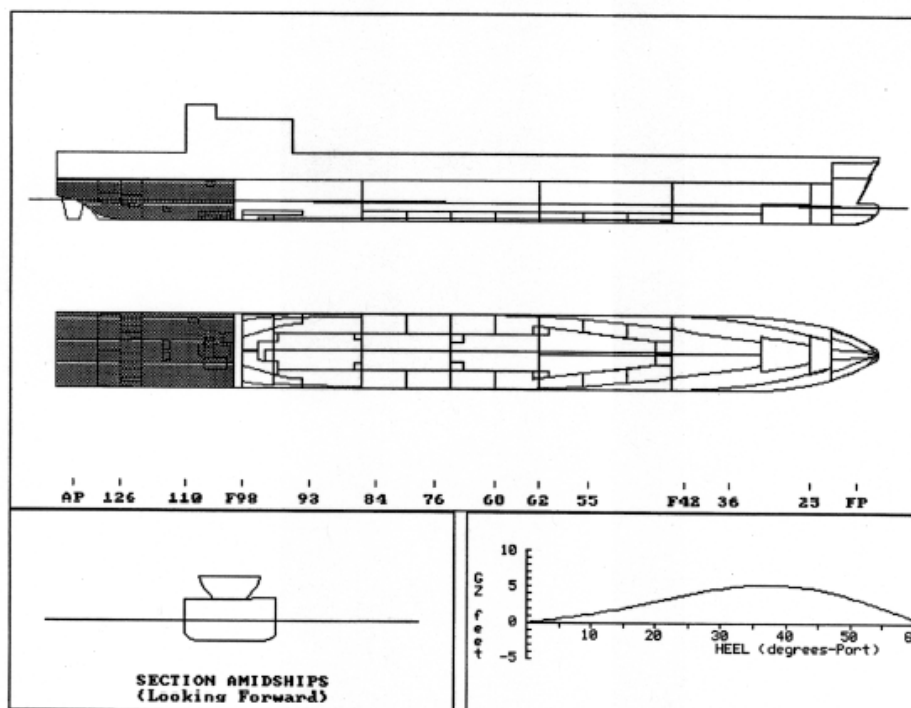
AP 126   110 F98   93   84   76   60 62   55   F42 36   23 FP

SECTION AMIDSHIPS
(Looking Forward)

GZ feet — HEEL (degrees-Port)

SHEAR & LONGITUDINAL BENDING STRESS SUMMARY
Stresses in ksi

FAIRED LINES PLAN
(Based on Direct Calculation from Hull Offsets)
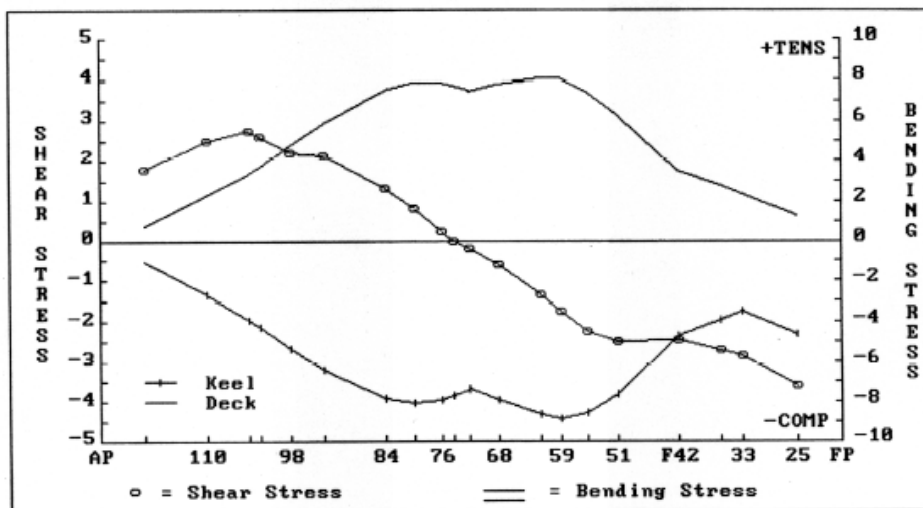
		SHEAR FORCES		BENDING MOMENTS		
	LOCATION	SHEAR	SHEAR STRESS	MOMENT	DK STRESS	KL STRESS
No.	ft-FP	LTons	ksi	ft-LTons	ksi	ksi
25	55.00A	-1,480	-3.59	50,980H	1.27	-4.63
33	121.00A	-2,762	-2.86	193,015H	2.36	-3.46
36	148.00A	-3,244	-2.72	274,422H	2.78	-3.89
F42	199.00A	-3,971	-2.45	459,671H	3.51	-4.69
51	274.00A	-3,645	-2.49	755,461H	6.27	-7.60
55	310.00A	-3,187	-2.24	879,529H	7.42	-8.58
59	343.00A	-2,528	-1.75	974,198H	8.04	-8.88
62	367.00A	-2,067	-1.36	1,028,989H	8.08	-8.66
68	418.00A	-1,020	-0.60	1,110,839H	7.81	-7.96
MS	452.50A	-376	-0.21	1,132,444H	7.44	-7.37
72	454.00A	-355	-0.20	1,132,977H	7.46	-7.39
Mx	473.51A	-0	-0.00	1,136,941H	7.71	-7.70
76	487.00A	413	0.24	1,134,208H	7.84	-7.89
80	520.00A	1,383	0.82	1,104,393H	7.87	-8.06
84	556.00A	2,175	1.29	1,039,943H	7.51	-7.86
93	631.00A	3,595	2.12	802,709H	5.87	-6.43
98	673.00A	3,779	2.20	653,060H	4.76	-5.36
F98	709.00A	4,510	2.59	504,137H	3.67	-4.23
104	724.00A	4,519	2.75	435,120H	3.34	-3.88
110	775.00A	3,301	2.49	238,163H	2.25	-2.68
126	851.00A	1,511	1.78	54,389H	0.78	-1.01

Maximum Shear Stress at 25:   -3.59 ksi
Maximum Deck Bending Stress at 62:   8.08 ksi
Maximum Keel Bending Stress at 59:   -8.88 ksi

RIGHTING ARM (GZ)
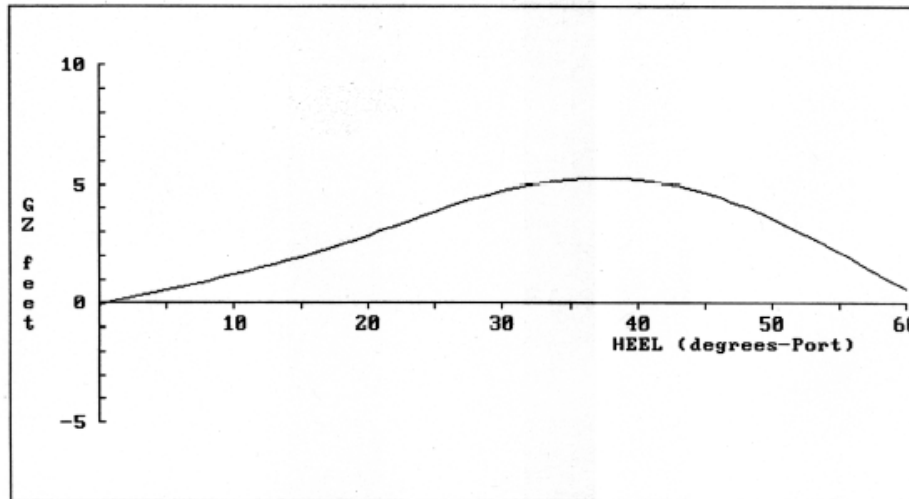
Stability Evaluation:

Static Heel Angle	0.6P	deg
Freeboard to Margin Line	63.15	ft	0.00 ft
Wind Heel Angle	2.3P	deg
Angle at Maximum GZ	37.4P	deg
Maximum GZ	5.28	ft
Range of Positive GZ	>59.4	deg
Gmt (upright damaged)	7.09	ft

(Based on Direct Calculation from Hull Offsets)
Freeboards are calculated perpendicular to the water surface

HOGGING MOC
AFT DAMAGE

FREE-FLOATING DAMAGED CONDITION

Damaged Compartments:

MACHY	LODT 8-103-4	ERWO 8-104-0	LOSM 8-104-1	LOSM 8-105-2	LORG 4-106-2
LORG 4-106-4	GTWD 8-107-0	BOLR CASCADE	FPST 7-112-1	LOPS 7-112-2	AFT
RGS 5-116-11	DP 6-116-1	SSDG 5-116-9	RGSL 5-116-7	ST 5-116-3	DTA 6-116-0
ST 5-116-1	SV 5-116-0	DP 6-116-4	POT 5-116-6	POT 5-116-8	DIS 5-116-10
GWT 5-126-1	APF 6-126-1	APF 6-126-2			

	DISPLACEMENT LTons	DRAFT FWD ft	DRAFT AFT ft	TRIM ft	HEEL deg.	UPRIGHT GMt ft
INTACT	46,452	26.87	26.52	0.35F	0.4S	10.95
DAMAGED	44,178	26.96	16.73	10.23F	0.7P	6.44

SECTION AMIDSHIPS
(Looking Forward)

SHEAR & LONGITUDINAL BENDING STRESS SUMMARY
Stresses in ksi

FAIRED LINES PLAN

Wave Height: 33.09 ft   Wave Position: 452.50A ft-FP
Wave Length: 905.00 ft

(Based on Direct Calculation from Hull Offsets)

195
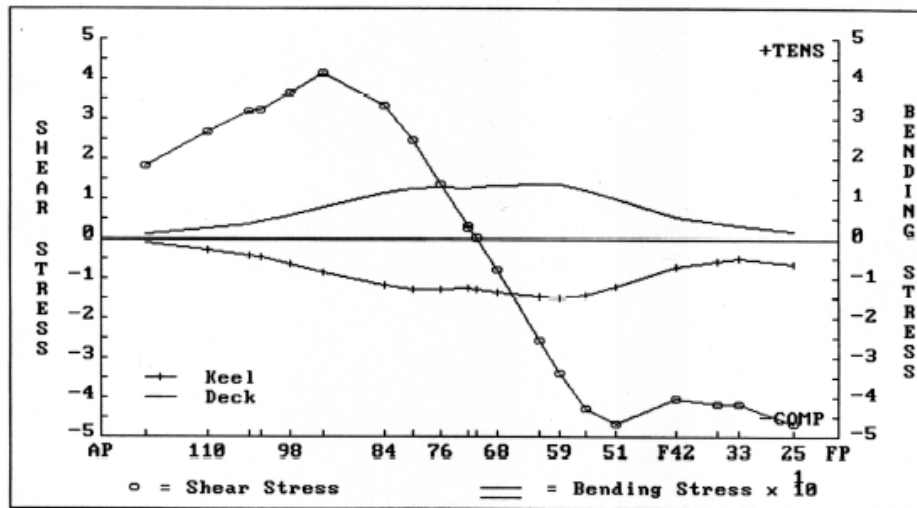
SHEAR & LONGITUDINAL BENDING STRESS SUMMARY
Stresses in ksi

FAIRED LINES PLAN

		SHEAR FORCES			BENDING MOMENTS	
	LOCATION	SHEAR	SHEAR STRESS	MOMENT	DK STRESS	KL STRESS
No.	ft-FP	LTons	ksi	ft-LTons	ksi	ksi
25	55.00A	-1,923	-4.67	64,991H	1.63	-6.16
33	121.00A	-4,041	-4.18	261,160H	3.19	-4.68
36	148.00A	-4,980	-4.17	383,193H	3.88	-5.44
F42	199.00A	-6,567	-4.05	679,458H	5.20	-6.94
51	274.00A	-6,825	-4.67	1,200,427H	9.97	-12.10
55	310.00A	-6,113	-4.30	1,436,113H	12.14	-14.02
59	343.00A	-4,909	-3.39	1,618,562H	13.37	-14.77
62	367.00A	-3,886	-2.55	1,724,052H	13.55	-14.53
68	418.00A	-1,319	-0.78	1,862,408H	13.12	-13.35
Mx	442.36A	2	0.00	1,876,285H	12.59	-12.56
MS	452.50A	457	0.25	1,873,646H	12.33	-12.20
72	454.00A	527	0.29	1,872,897H	12.35	-12.24
76	487.00A	2,324	1.34	1,828,928H	12.66	-12.74
80	520.00A	4,165	2.46	1,720,716H	12.28	-12.58
84	556.00A	5,608	3.33	1,542,476H	11.16	-11.68
93	631.00A	7,001	4.13	1,036,064H	7.58	-8.31
98	673.00A	6,229	3.62	760,985H	5.56	-6.26
F98	709.00A	5,600	3.22	546,892H	3.99	-4.60
104	724.00A	5,191	3.16	465,855H	3.58	-4.16
110	775.00A	3,528	2.66	244,115H	2.31	-2.75
126	851.00A	1,528	1.80	55,218H	0.80	-1.03

Maximum Shear Stress at 51:   -4.67 ksi
Maximum Deck Bending Stress at 62:   13.55 ksi
Maximum Keel Bending Stress at 59:   -14.77 ksi

RIGHTING ARM (GZ)

Stability Evaluation:

Static Heel Angle	0.7P deg	
Freeboard to Margin Line	65.76 ft	0.00 ft
Wind Heel Angle	2.9P deg	
Angle at Maximum GZ	37.9P deg	
Maximum GZ	4.49 ft	
Range of Positive GZ	>59.3 deg	
Gmt (upright damaged)	6.44 ft	

(Based on Direct Calculation from Hull Offsets)

Freeboards are calculated perpendicular to the water surface

SAGGING MOC
AFT DAMAGE

FREE-FLOATING DAMAGED CONDITION

Damaged Compartments:

MACHY	LODT 8-103-4	ERWO 8-104-0	LOSM 8-104-1	LOSM 8-105-2	LORG 4-106-2
LORG 4-106-4	GTWD 8-107-0	BOLR CASCADE	FPST 7-112-1	LOPS 7-112-2	AFT
RGS 5-116-11	DP 6-116-1	SSDG 5-116-9	RGSL 5-116-7	ST 5-116-3	DTA 6-116-0
ST 5-116-1	SV 5-116-0	DP 6-116-4	POT 5-116-6	POT 5-116-8	DIS 5-116-10
GWT 5-126-1	APF 6-126-1	APF 6-126-2			

	DISPLACEMENT LTons	DRAFT FWD ft	DRAFT AFT ft	TRIM ft	HEEL deg.	UPRIGHT GMt ft
INTACT	46,452	26.87	26.52	0.35F	0.4S	10.95
DAMAGED	61,850	25.96	43.73	17.77A	0.3S	8.88

SHEAR & LONGITUDINAL BENDING STRESS SUMMARY
Stresses in ksi

FAIRED LINES PLAN

Wave Height: 33.09 ft   Wave Position: 0.00   ft-FP
Wave Length: 905.00 ft
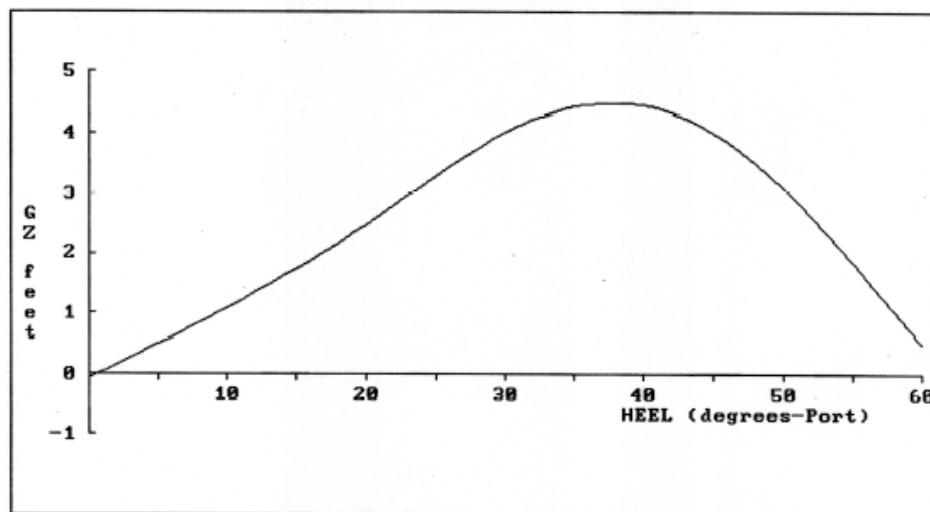
(Based on Direct Calculation from Hull Offsets)

200
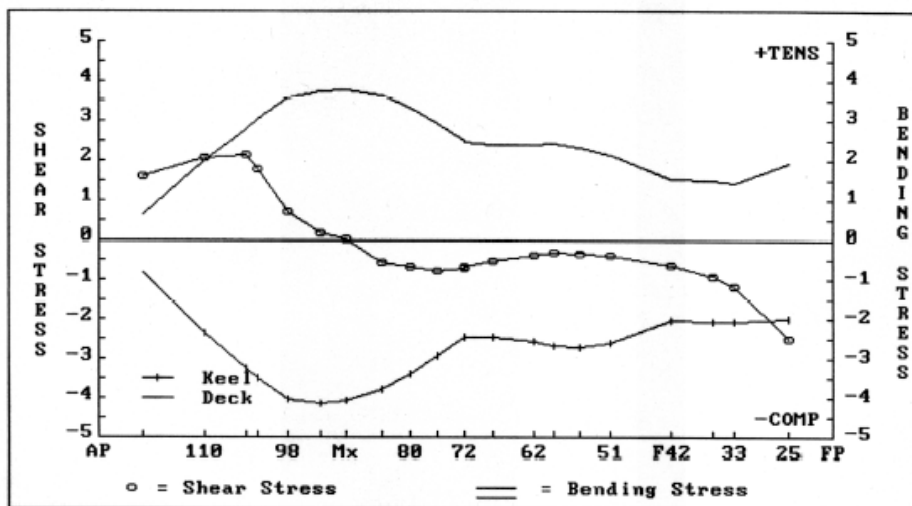
SHEAR & LONGITUDINAL BENDING STRESS SUMMARY
Stresses in ksi

FAIRED LINES PLAN

No.	LOCATION ft-FP	SHEAR FORCES SHEAR LTons	SHEAR STRESS ksi	BENDING MOMENTS MOMENT ft-LTons	DK STRESS ksi	KL STRESS ksi
25	55.00A	-1,033	-2.51	40,637H	1.93	-1.99
33	121.00A	-1,127	-1.17	116,379H	1.41	-2.07
36	148.00A	-1,079	-0.90	146,435H	1.47	-2.07
F42	199.00A	-1,025	-0.63	199,572H	1.51	-2.03
51	274.00A	-537	-0.37	259,648H	2.14	-2.60
55	310.00A	-492	-0.35	277,686H	2.33	-2.69
59	343.00A	-449	-0.31	293,529H	2.41	-2.66
62	367.00A	-548	-0.36	305,114H	2.38	-2.55
68	418.00A	-885	-0.52	343,282H	2.40	-2.45
MS	452.50A	-1,219	-0.67	377,968H	2.47	-2.45
72	454.00A	-1,239	-0.68	379,795H	2.49	-2.47
76	487.00A	-1,350	-0.78	424,134H	2.92	-2.94
80	520.00A	-1,134	-0.67	465,708H	3.30	-3.38
84	556.00A	-945	-0.56	503,955H	3.62	-3.79
Mx	599.15A	6	0.00	524,928H	3.80	-4.08
93	631.00A	304	0.18	517,640H	3.76	-4.13
98	673.00A	1,209	0.70	493,348H	3.58	-4.03
F98	709.00A	3,095	1.78	417,681H	3.02	-3.49
104	724.00A	3,508	2.13	365,947H	2.79	-3.25
110	775.00A	2,716	2.05	210,547H	1.98	-2.36
126	851.00A	1,352	1.59	44,273H	0.63	-0.82

Maximum Shear Stress at 25:   -2.51 ksi
Maximum Deck Bending Stress at Mx: 3.80 ksi
Maximum Keel Bending Stress at 93:   -4.13 ksi

RIGHTING ARM (GZ)
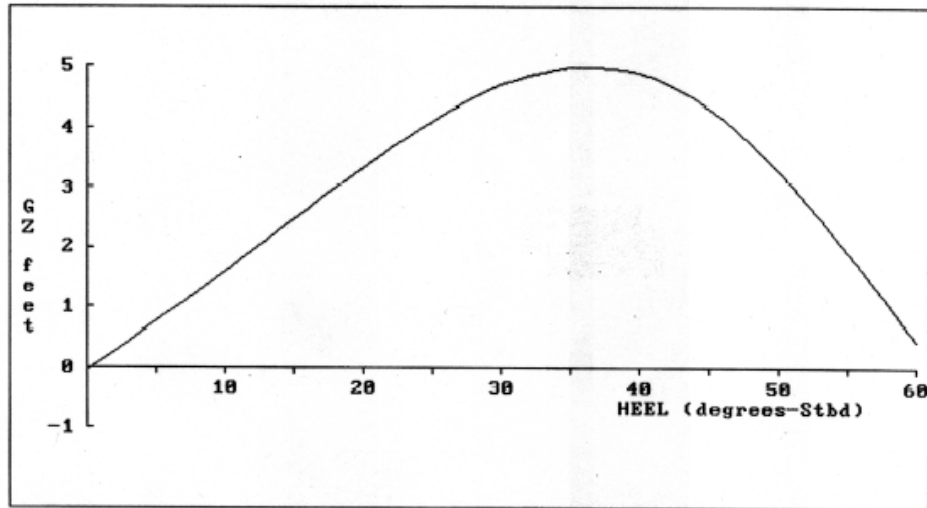
Stability Evaluation:

Static Heel Angle	0.3S deg	
Freeboard to Margin Line	48.59 ft	0.00 ft
Wind Heel Angle	1.3S deg	
Angle at Maximum GZ	36.4S deg	
Maximum GZ	4.98 ft	
Range of Positive GZ	>59.7 deg	
Gmt (upright damaged)	8.88 ft	

(Based on Direct Calculation from Hull Offsets)
Freeboards are calculated perpendicular to the water surface

Appendix G
SWAN Seakeeping Analysis

12 KNOTS

RAO for Heave, Pitch and Roll

Pitch U = 12 knots — Roll U = 12 knots — Heave U = 12 knots — Pierson Moskowitz Sea Spectrum x5
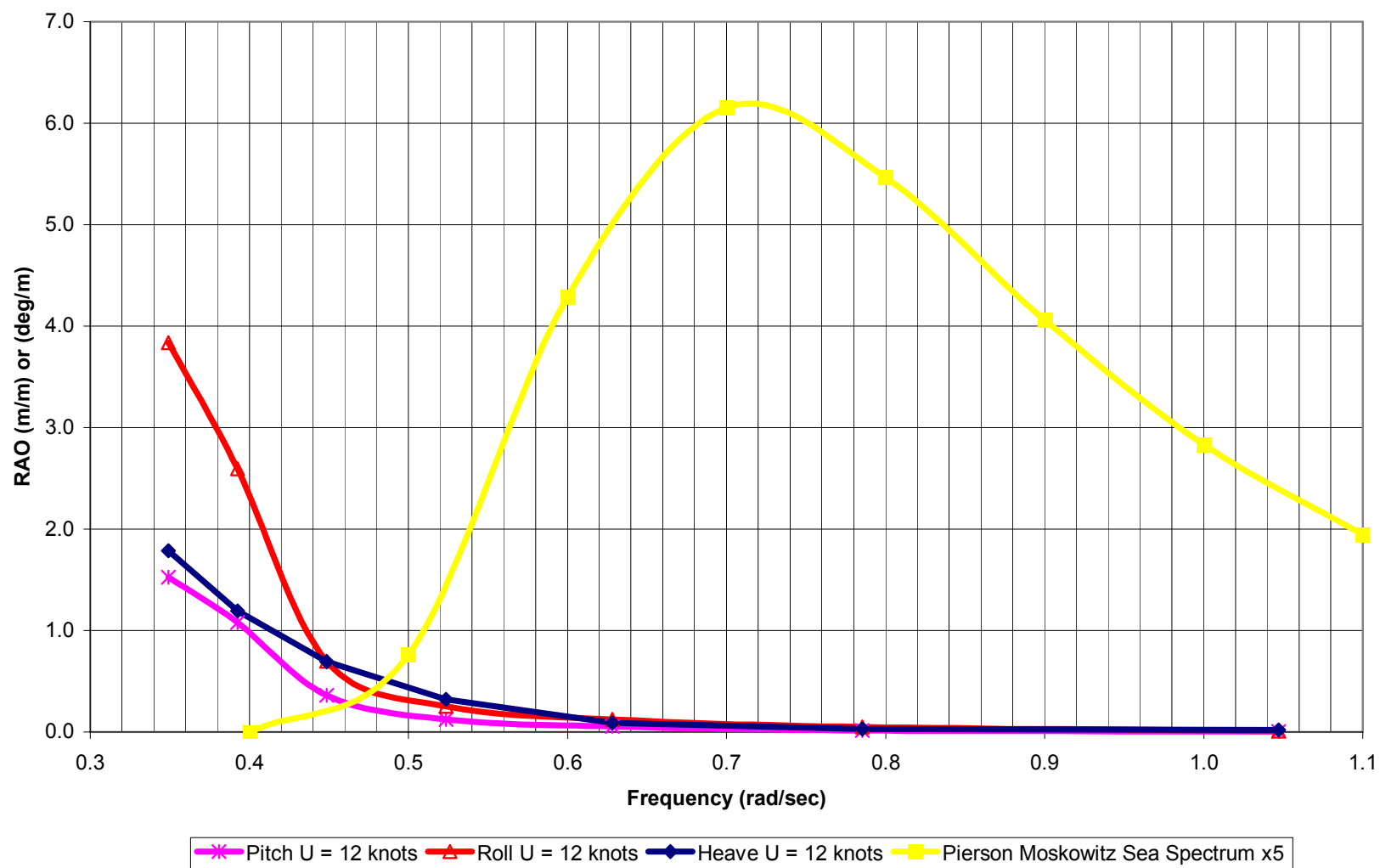
Response Spectra

μ = 150 deg
P.M. Sea Spectrum
Sea State 5

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************************************************************
*                                                          *
*               SWAN2 2002  SOLVE                          *
*                                                          *
*                                                          *
*               Copyright (C) 2002                         *
*         Massachusetts Institute of Technology            *
*                                                          *
************************************************************


------------------------------------------------------------
                   GRID INFORMATION
          Name    :   SOF
------------------------------------------------------------
      Sheet#    NP1     NP2      NP      KP      MP
        1       16      58     928       3       0
        2        4      30     120       3       0
        3       21      30     630       2       1
        4       30      30     900       1       0
------------------------------------------------------------


------------------------------------------------------------
            PRINCIPAL HYDROSTATIC PARTICULARS
  density (kg/m^3)= 1025.000  gravity (m/s^2)=   9.800
------------------------------------------------------------
        Waterline Length     (m)   :    2.525E+2
        Waterline Beam       (m)   :    3.224E+1
        Maximum Draft        (m)   :    6.888E+0
        Displacement       (m^3)   :    2.496E+4
        Wetted Surface Area (m^2)  :    7.148E+3
        LCB (from origin)    (m)   :   -1.997E+0
        TCB (from origin)    (m)   :    0.000E+0
        VCB (from origin)    (m)   :   -2.526E+0
------------------------------------------------------------
        Waterplane Area     (m^2)  :    6.070E+3
        LCF (from origin)    (m)   :   -1.333E+1
        Metacentric height   (m)   :    6.865E+0
------------------------------------------------------------
        Mass                 (kg)  :    3.992E+7
        Mass/density       (m^3)   :    3.895E+4
        LCG (from origin)    (m)   :    1.347E+2
        TCG (from origin)    (m)   :    1.545E-1
        VCG (from origin)    (m)   :    2.720E+0
        Radii of Gyration    (m)   :    1.689E+1 (roll)
           (about CG)        (m)   :    8.068E+1 (pitch)
                             (m)   :    2.816E+1 (yaw)
------------------------------------------------------------
```

18 KNOTS

RAO for Heave, Pitch and Roll

209

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    ***********************************************************
    *                                                         *
    *                SWAN2 2002   SOLVE                        *
    *                                                         *
    *                                                         *
    *                Copyright (C) 2002                       *
    *         Massachusetts Institute of Technology           *
    *                                                         *
    ***********************************************************


    -----------------------------------------------------------
                       GRID INFORMATION
              Name    :   SOF
    -----------------------------------------------------------

         Sheet#    NP1     NP2      NP      KP      MP
            1       16      58     928       3       0
            2        4      30     120       3       0
            3       21      30     630       2       1
            4       30      30     900       1       0
    -----------------------------------------------------------


    -----------------------------------------------------------
               PRINCIPAL HYDROSTATIC PARTICULARS
     density (kg/m^3)= 1025.000  gravity (m/s^2)=   9.800
    -----------------------------------------------------------
            Waterline Length     (m)   :    2.525E+2
            Waterline Beam       (m)   :    3.224E+1
            Maximum Draft        (m)   :    6.888E+0
            Displacement        (m^3)  :    2.496E+4
            Wetted Surface Area (m^2)  :    7.148E+3
            LCB (from origin)    (m)   :   -1.997E+0
            TCB (from origin)    (m)   :    0.000E+0
            VCB (from origin)    (m)   :   -2.526E+0
    -----------------------------------------------------------
            Waterplane Area     (m^2)  :    6.070E+3
            LCF (from origin)    (m)   :   -1.333E+1
            Metacentric height   (m)   :    6.865E+0
    -----------------------------------------------------------
            Mass                (kg)   :    3.992E+7
            Mass/density        (m^3)  :    3.895E+4
            LCG (from origin)    (m)   :    1.347E+2
            TCG (from origin)    (m)   :    1.545E-1
            VCG (from origin)    (m)   :    2.720E+0
            Radii of Gyration    (m)   :    1.689E+1 (roll)
               (about CG)        (m)   :    8.068E+1 (pitch)
                                 (m)   :    2.816E+1 (yaw)
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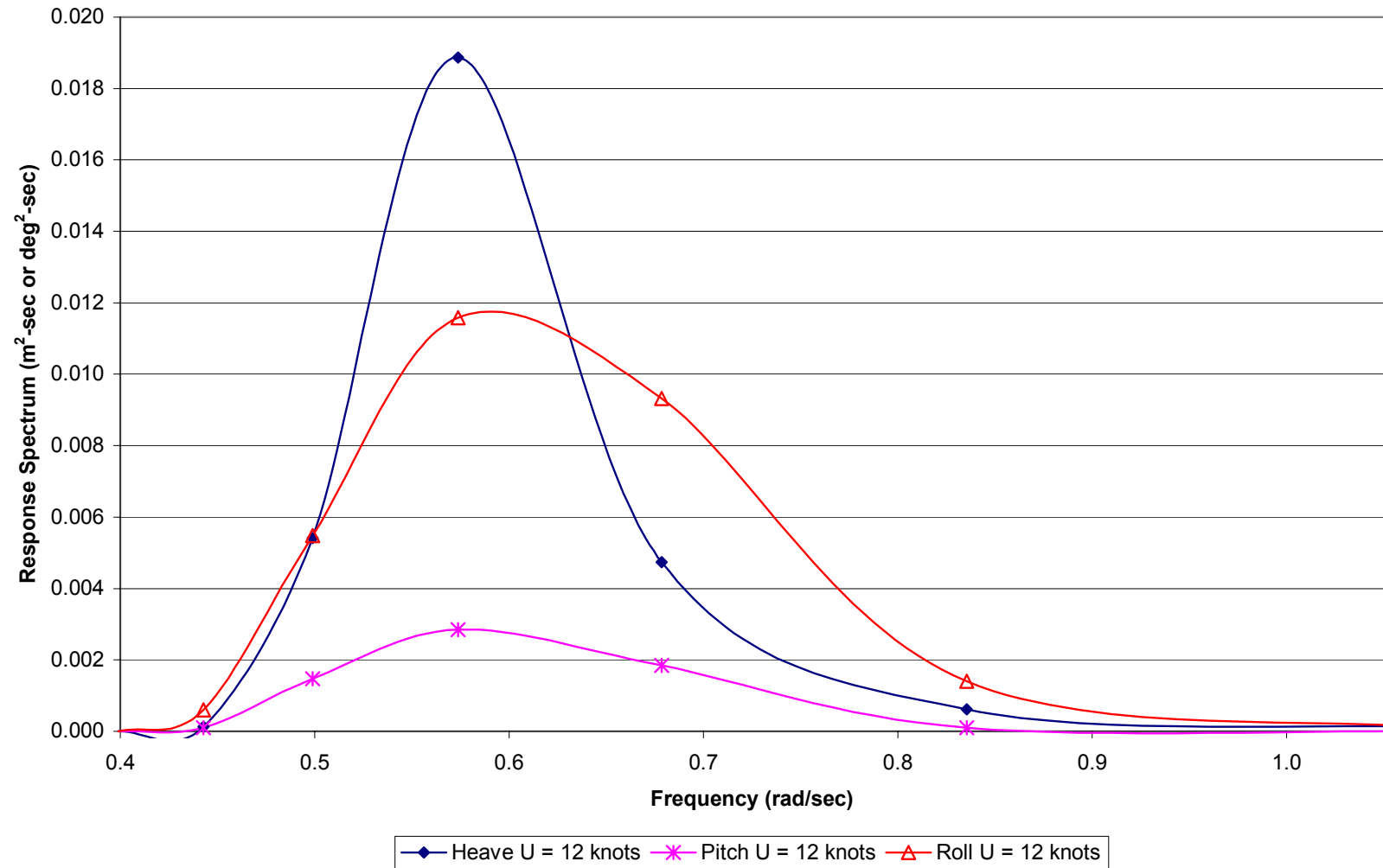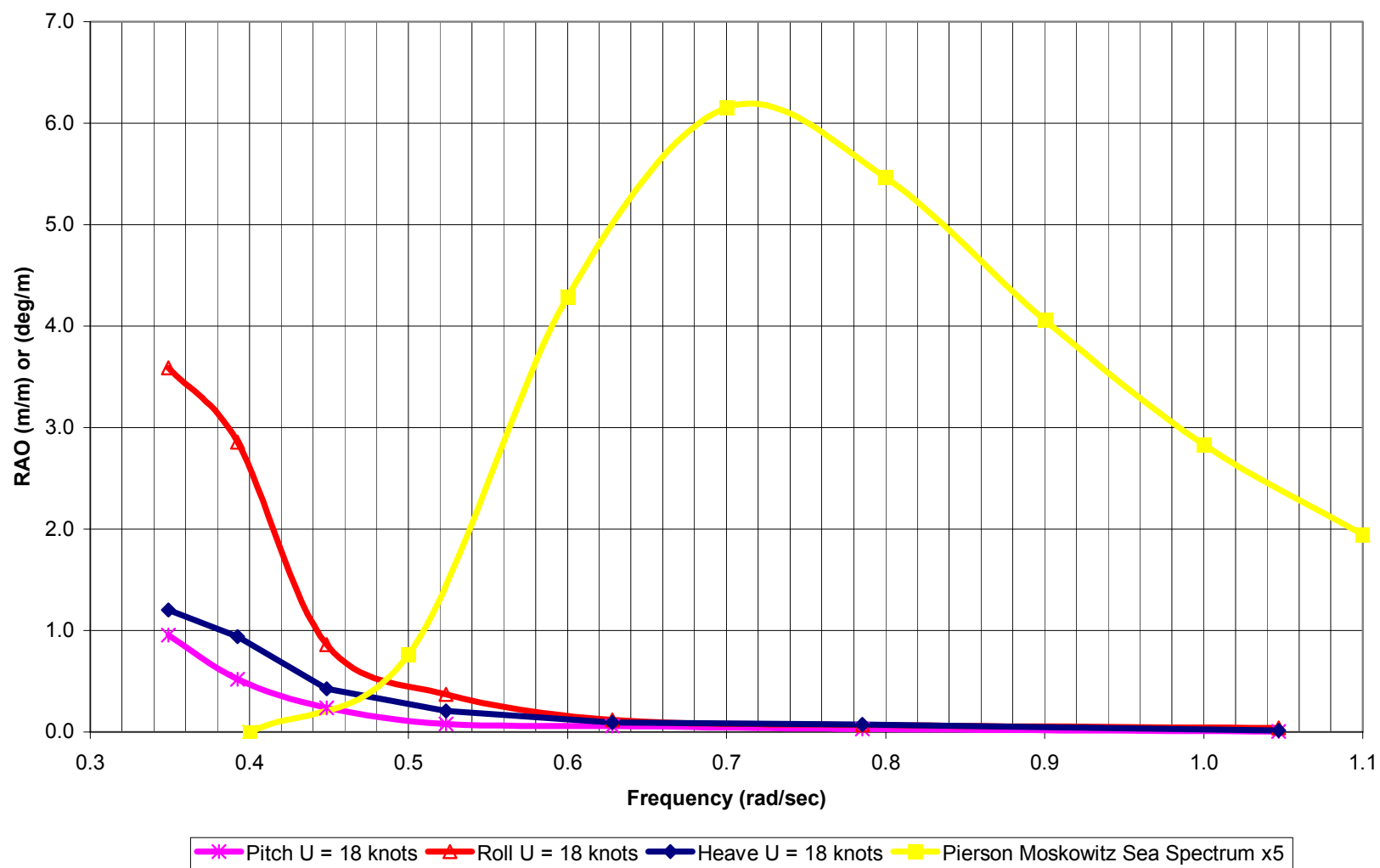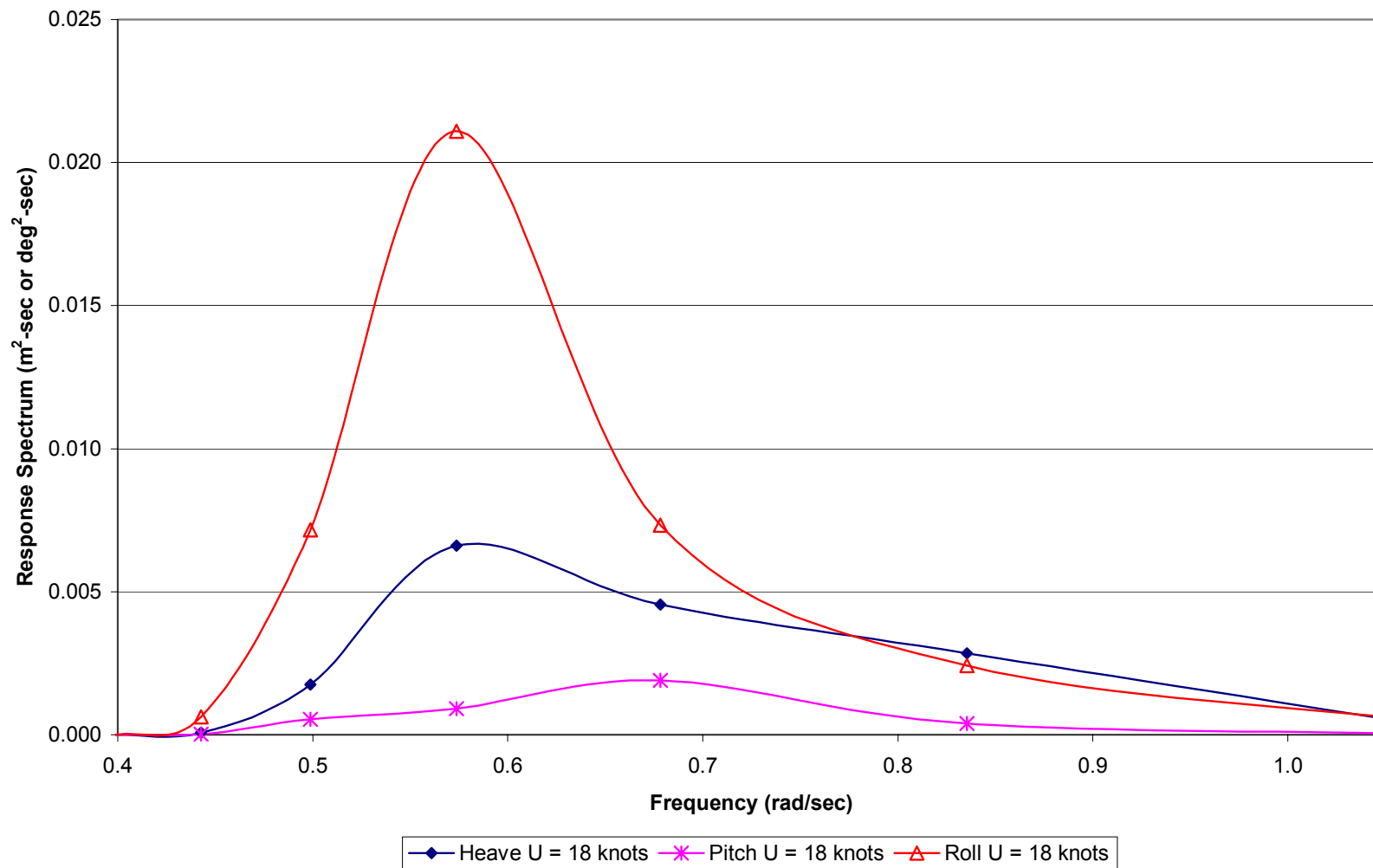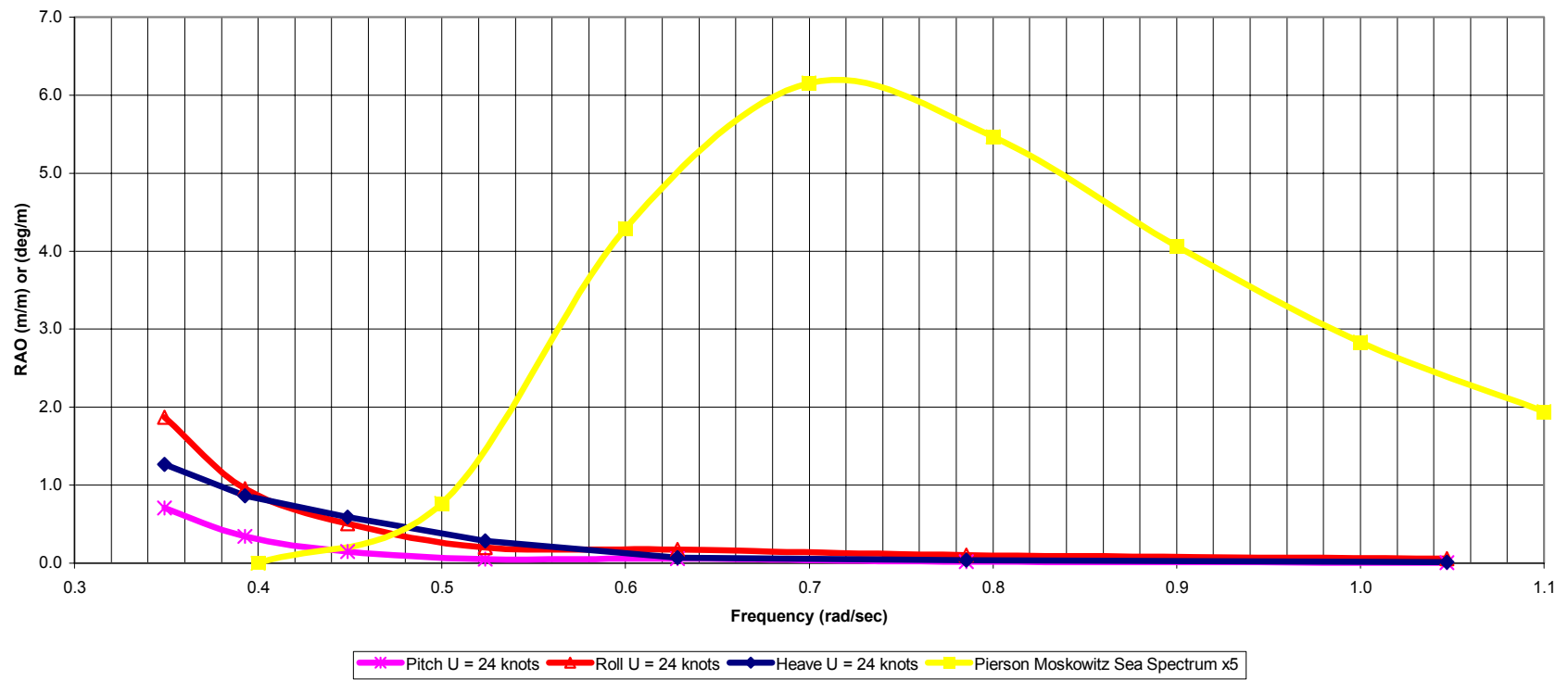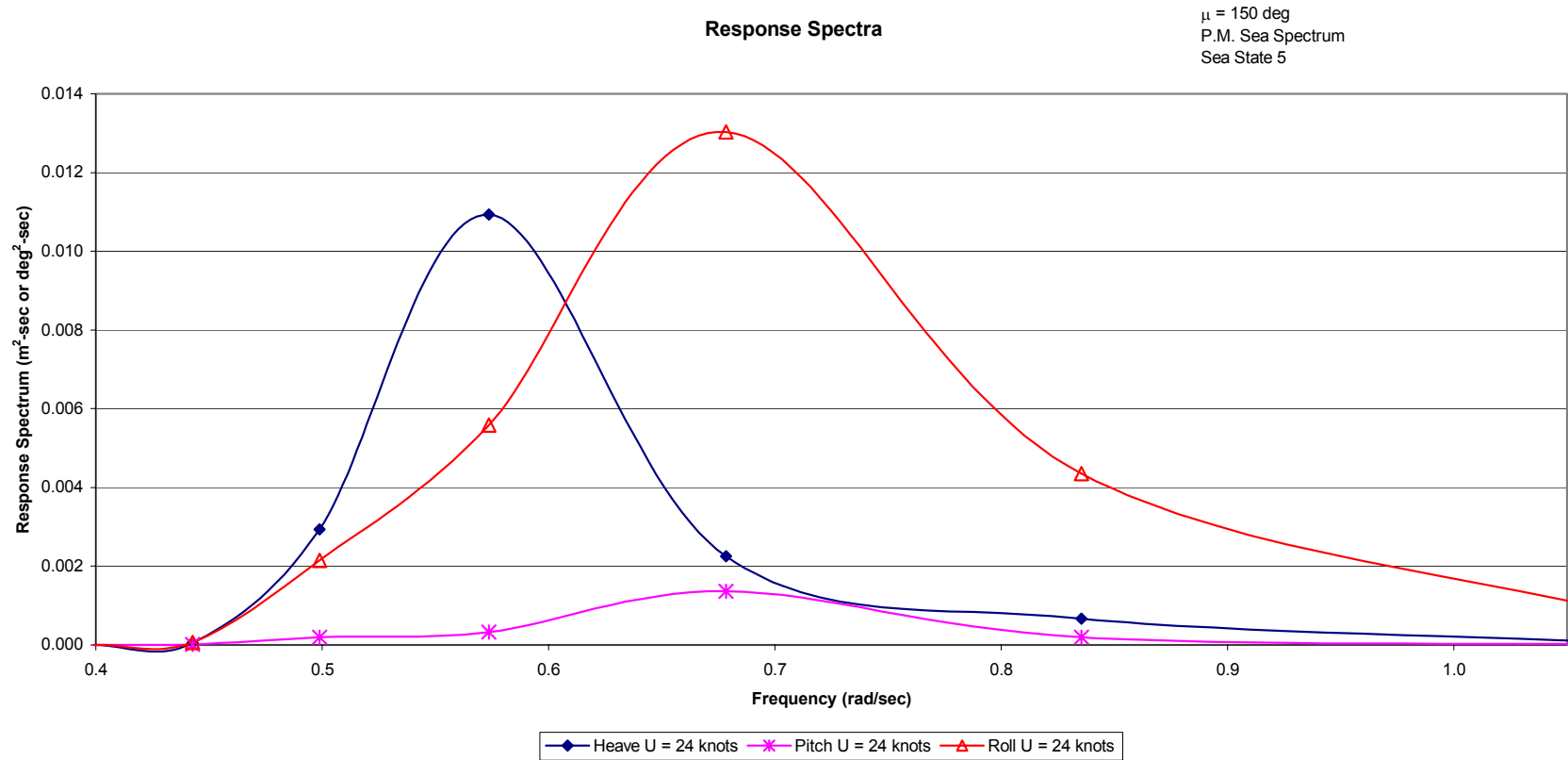
211

24 KNOTS

RAO for Heave, Pitch and Roll

Response Spectra

μ = 150 deg
P.M. Sea Spectrum
Sea State 5

214

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  **********************************************************
  *                                                        *
  *                SWAN2 2002  SOLVE                        *
  *                                                        *
  *                                                        *
  *                Copyright (C) 2002                      *
  *        Massachusetts Institute of Technology           *
  *                                                        *
  **********************************************************


  ------------------------------------------------------------
                    GRID INFORMATION
            Name    :   SOF
  ------------------------------------------------------------
        Sheet#    NP1     NP2      NP      KP      MP
          1       16      58      928       3       0
          2        4      30      120       3       0
          3       21      30      630       2       1
          4       30      30      900       1       0
  ------------------------------------------------------------


  ------------------------------------------------------------
              PRINCIPAL HYDROSTATIC PARTICULARS
    density (kg/m^3)= 1025.000  gravity (m/s^2)=   9.800
  ------------------------------------------------------------
          Waterline Length      (m)   :    2.525E+2
          Waterline Beam        (m)   :    3.224E+1
          Maximum Draft         (m)   :    6.888E+0
          Displacement        (m^3)   :    2.496E+4
          Wetted Surface Area (m^2)   :    7.148E+3
          LCB (from origin)     (m)   :   -1.997E+0
          TCB (from origin)     (m)   :    0.000E+0
          VCB (from origin)     (m)   :   -2.526E+0
  ------------------------------------------------------------
          Waterplane Area     (m^2)   :    6.070E+3
          LCF (from origin)     (m)   :   -1.333E+1
          Metacentric height    (m)   :    6.865E+0
  ------------------------------------------------------------
          Mass                 (kg)   :    3.992E+7
          Mass/density        (m^3)   :    3.895E+4
          LCG (from origin)     (m)   :    1.347E+2
          TCG (from origin)     (m)   :    1.545E-1
          VCG (from origin)     (m)   :    2.720E+0
          Radii of Gyration     (m)   :    1.689E+1 (roll)
             (about CG)         (m)   :    8.068E+1 (pitch)
                                (m)   :    2.816E+1 (yaw)
  ------------------------------------------------------------
```

Appendix H
Cost Models

COST MODEL--Construction LMSR

MIT 13A

Definitions (units): $Mdol := coul$ $Bdol := 1000 \cdot Mdol$ $Kdol := \dfrac{Mdol}{1000}$ $dol := \dfrac{Kdol}{1000}$

$lton := 2240 \cdot lb$

$CNA := 2.2$ $CND := 0.5$

1. Single Digit Weight Summary: $i1 := 100, 200 .. 700$

Base Weight

$WA_{100} := 25332.18 \cdot lton$ $WA_{400} := 61.06 \cdot lton$ $WA_{700} := 4.15 \cdot lton$

$WA_{200} := 1984.52 \cdot lton$ $WA_{500} := 4074.85 \cdot lton$

$WA_{300} := 668.04 \cdot lton$ $WA_{600} := 1771.71 \cdot lton$

2. Additional Characteristics:

Total Weight Added:

$WAdd := \left(\displaystyle\sum_{i1} WA_{i1} \right)$ $WAdd = 31911.99 \, lton$

Manning: (crew + air detachment + staff)   Officers: $N_O := 8$ Enlisted: $N_E := 22$

Officers: CPO's: $N_{C_2} := 0$ Enlisted: $N_{C_3} := N_E - N_{C_2}$

Ship Service Life: $L_S := 30$ Initial Operational Capability: $Y_{IOC} := 2004$

Total Ship Acquisition: $N_S := 1$ Production Rate (per year): $R_P := 1$

3. Inflation:

Base Year: $Y_B := 2003$ $iy := 1 .. Y_B - 1998$

Average Inflation Rate (%): $R_I := 3.$ $F_I := \displaystyle\prod_{iy} \left(1 + \dfrac{R_I}{100} \right)$ $F_I = \blacksquare$
(from 1981)

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4. Lead Ship Cost:

Lead Ship Addition Cost - Shipbuilder Portion:

SWBS costs: includes escalation estimate

Structure
$$K_{N1} := \frac{.55 \cdot \text{Mdol}}{\text{lton}^{.772}}$$
$$CA_{L_{100}} := .03395 \cdot F_I \cdot K_{N1} \cdot 2.2 \cdot \left(WA_{100}\right)^{.772}$$
$$CA_{L_{100}} = \blacksquare \text{ Mdol}$$

+ Propulsion
$$K_{N2} := \frac{1.2 \cdot \text{Mdol}}{\text{lton}^{.808}}$$
$$CA_{L_{200}} := .00186 \cdot F_I \cdot K_{N2} \cdot 2.2 \cdot \left(WA_{200}\right)^{.808}$$
$$CA_{L_{200}} = \blacksquare \text{ Mdol}$$

+ Electric
$$K_{N3} := \frac{1.0 \cdot \text{Mdol}}{\text{lton}^{.91}}$$
$$CA_{L_{300}} := .07505 \cdot F_I \cdot K_{N3} \cdot 2.2 \cdot \left(WA_{300}\right)^{.91}$$
$$CA_{L_{300}} = \blacksquare \text{ Mdol}$$

+ Command, Control, Surveillance

$$K_{N4} := \frac{2.0 \cdot \text{Mdol}}{\text{lton}^{.617}}$$
$$CA_{L_{400}} := .10857 \cdot F_I \cdot K_{N4} \cdot 2.2 \cdot \left(WA_{400}\right)^{.617}$$
$$CA_{L_{400}} = \blacksquare \text{ Mdol}$$

(less payload GFM cost)

+ Auxiliary
$$K_{N5} := \frac{1.5 \cdot \text{Mdol}}{\text{lton}^{.782}}$$
$$CA_{L_{500}} := .09487 \cdot F_I \cdot K_{N5} \cdot 2.2 \cdot \left(WA_{500}\right)^{.782}$$
$$CA_{L_{500}} = \blacksquare \text{ Mdol}$$

+ Outfit
$$K_{N6} := \frac{1.0 \cdot \text{Mdol}}{\text{lton}^{.784}}$$
$$CA_{L_{600}} := .09859 \cdot F_I \cdot K_{N6} \cdot 2.2 \cdot \left(WA_{600}\right)^{.784}$$
$$CA_{L_{600}} = \blacksquare \text{ Mdol}$$

+ Armament
$$K_{N7} := \frac{1.0 \cdot \text{Mdol}}{\text{lton}^{.987}}$$
$$CA_{L_{700}} := .00838 \cdot F_I \cdot K_{N7} \cdot 2.2 \cdot \left(WA_{700}\right)^{.987}$$
$$CA_{L_{700}} = \blacksquare \text{ Mdol}$$

(Less payload GFM cost)

+ Integration/Engineering: (Lead ship includes detail design engineering + plans for class)

$$K_{N8} := \frac{10. \cdot \text{Mdol}}{\text{Mdol}^{1.099}}$$
$$CA_{L_{800}} := .034 \cdot K_{N8} \cdot 0.5 \cdot \left(\left(\sum_{i1} CA_{L_{i1}}\right)\right)^{1.099}$$
$$CA_{L_{800}} = \blacksquare \text{ Mdol}$$

+ Ship Assembly + Support: (Lead ship includes all tooling, jigs, special facilities for class)

$$K_{N9} := \frac{2.0 \cdot \text{Mdol}}{(\text{Mdol})^{.839}}$$
$$CA_{L_{900}} := .135 \cdot K_{N9} \cdot 0.5 \cdot \left(\left(\sum_{i1} CA_{L_{i1}}\right)\right)^{.839}$$
$$CA_{L_{900}} = \blacksquare \text{ Mdol}$$

= Total Cost for addition of all strutures

$$CAtot := \sum_{i1} CA_{L_{i1}} + CA_{L_{800}} + CA_{L_{900}}$$

$$CAtot = \blacksquare \text{ Mdol}$$

= Total Cost for conversion of SOF

$CTOT := CAtot$ $\qquad\qquad CTOT = \blacksquare\ Mdol$

+ Profit:

$F_P := .10$ $\qquad C_{LP} := F_P \cdot CTOT$ $\qquad C_{LP} = \blacksquare\ Mdol$

= <u>Lead Ship Price</u>:

$P_L := CTOT + C_{LP}$ $\qquad\qquad$ $P_L = \blacksquare\ Mdol$

= <u>*Total Shipbuilder Portion:*</u>

$C_{SB} := P_L$ $\qquad\qquad C_{SB} = \blacksquare\ Mdol$

b. Lead Ship Cost - Government Portion

> This is where the cost of SOF equipment would go. Zeroed for this evaluation.
> **SOF will provide for their own equipment.**

+ Ordnance and Electrical GFE:
  (Military Payload GFE)

$C_{LMPG} := 0 \cdot Mdol$

$C_{LMPG} = \blacksquare\ Mdol$ $\qquad$ (or incl actual cost if known)

+ Outfittimg Cost :

$C_{LOUT} := .02 \cdot P_L$ $\qquad C_{LOUT} = \blacksquare\ Mdol$

= <u>*Total Government Portion:*</u>

$C_{LGOV} := C_{LMPG} + C_{LOUT}$ $\qquad\qquad C_{LGOV} = \blacksquare\ Mdol$

c. Total Lead Ship End Cost: *(Must always be less than appropriation)*

* <u>*Total End Cost:*</u> $\qquad C_{LEND} := C_{SB}$ $\qquad\qquad C_{LEND} = \blacksquare\ Mdol$

d. Total Lead Ship Acquisition Cost:

+ Post-Delivery Cost (PSA): $\qquad C_{LPDEL} := .05 \cdot P_L$ $\qquad C_{LPDEL} = \blacksquare\ Mdol$

= <u>Total Lead Ship Acquisition Cost:</u> $C_{LA} := 0.5(C_{LEND} + C_{LPDEL}) + C_{LGOV}$

$$C_{LA} = \blacksquare \, Mdol$$

e.Introduction of the correction factor

This factor introduces a correction to the price of a follow on LMSR new construction ship, which is $250 million according to Avondale Industrie's seventh ship contract.
The cost that our math model calculates is $434.292million. (based on a weight break down for <u>Navy Combatants</u>)

= <u>Correction Factor: ε</u>

$$\varepsilon := \frac{250}{434.292}$$

$$\varepsilon = \blacksquare$$

<u>Total Lead Ship Acquisition Cost (corrected):</u>

$$C_{LAc} := C_{LA} \cdot \varepsilon$$

$$C_{LAc} = \blacksquare \, Mdol$$

COST MODEL--Construction SOF

MIT 13A

Definitions (units):
$$Mdol := coul \qquad Bdol := 1000 \cdot Mdol \qquad Kdol := \frac{Mdol}{1000} \qquad dol := \frac{Kdol}{1000}$$

$$lton := 2240 \cdot lb$$

$$CNA := 2.2 \qquad CND := 0.5$$

1. Single Digit Weight Summary:
$$i1 := 100, 200 .. 700$$

<mark>Base Weight</mark>

$$WA_{100} := 29114.79 \cdot lton \qquad WA_{400} := 137.25 \cdot lton \qquad WA_{700} := 42.21 \cdot lton$$

$$WA_{200} := 1984.52 \cdot lton \qquad WA_{500} := 4831.93 \cdot lton$$

$$WA_{300} := 707.75 \cdot lton \qquad WA_{600} := 3078.57 \cdot lton$$

2. Additional Characteristics:

Total Weight Added:
$$WAdd := \left(\sum_{i1} WA_{i1} \right) \qquad WAdd = \blacksquare \; lton$$

Manning: (crew + air detachment + staff)   Officers: $N_O := 8$ Enlisted: $N_E := 22$

Officers: CPO's: $N_{C_2} := 0$ Enlisted: $N_{C_3} := N_E - N_{C_2}$

Ship Service Life: $L_S := 30$ Initial Operational Capability: $Y_{IOC} := 2004$

Total Ship Acquisition: $N_S := 1$ Production Rate (per year): $R_P := 1$

3. Inflation:

Base Year: $Y_B := 2003 \qquad iy := 1 .. Y_B - 1998$

Average Inflation Rate (%): $R_I := 3.$ $F_I := \prod_{iy} \left(1 + \frac{R_I}{100} \right) \qquad F_I = \blacksquare$
(from 1981)

4. Lead Ship Cost:

Lead Ship Addition Cost - Shipbuilder Portion:

SWBS costs: includes escalation estimate

Structure $\quad K_{N1} := \dfrac{.55 \cdot Mdol}{lton^{.772}} \quad CA_{L_{100}} := .03395 \cdot F_I \cdot K_{N1} \cdot 2.2 \cdot \left(WA_{100}\right)^{.772} \quad CA_{L_{100}} = \blacksquare\ Mdol$

+ Propulsion $\quad K_{N2} := \dfrac{1.2 \cdot Mdol}{lton^{.808}} \quad CA_{L_{200}} := .00186 \cdot F_I \cdot K_{N2} \cdot 2.2 \cdot \left(WA_{200}\right)^{.808} \quad CA_{L_{200}} = \blacksquare\ Mdol$

+ Electric $\quad K_{N3} := \dfrac{1.0 \cdot Mdol}{lton^{.91}} \quad CA_{L_{300}} := .07505 \cdot F_I \cdot K_{N3} \cdot 2.2 \cdot \left(WA_{300}\right)^{.91} \quad CA_{L_{300}} = \blacksquare\ Mdol$

+ Command, Control, Surveillance

$\quad K_{N4} := \dfrac{2.0 \cdot Mdol}{lton^{.617}} \quad CA_{L_{400}} := .10857 \cdot F_I \cdot K_{N4} \cdot 2.2 \cdot \left(WA_{400}\right)^{.617} \quad CA_{L_{400}} = \blacksquare\ Mdol$

(less payload GFM cost)

+ Auxiliary $\quad K_{N5} := \dfrac{1.5 \cdot Mdol}{lton^{.782}} \quad CA_{L_{500}} := .09487 \cdot F_I \cdot K_{N5} \cdot 2.2 \cdot \left(WA_{500}\right)^{.782} \quad CA_{L_{500}} = \blacksquare\ Mdol$

+ Outfit $\quad K_{N6} := \dfrac{1.0 \cdot Mdol}{lton^{.784}} \quad CA_{L_{600}} := .09859 \cdot F_I \cdot K_{N6} \cdot 2.2 \cdot \left(WA_{600}\right)^{.784} \quad CA_{L_{600}} = \blacksquare\ Mdol$

+ Armament $\quad K_{N7} := \dfrac{1.0 \cdot Mdol}{lton^{.987}} \quad CA_{L_{700}} := .00838 \cdot F_I \cdot K_{N7} \cdot 2.2 \cdot \left(WA_{700}\right)^{.987} \quad CA_{L_{700}} = \blacksquare\ Mdol$

(Less payload GFM cost)

+ Integration/Engineering: (Lead ship includes detail design engineering + plans for class)

$\quad K_{N8} := \dfrac{10. \cdot Mdol}{Mdol^{1.099}} \quad CA_{L_{800}} := .034 \cdot K_{N8} \cdot 0.5 \cdot \left(\left(\sum_{i1} CA_{L_{i1}}\right)\right)^{1.099} \quad CA_{L_{800}} = \blacksquare\ Mdol$

+ Ship Assembly + Support: (Lead ship includes all tooling, jigs, special facilities for class)

$\quad K_{N9} := \dfrac{2.0 \cdot Mdol}{(Mdol)^{.839}} \quad CA_{L_{900}} := .135 \cdot K_{N9} \cdot 0.5 \cdot \left(\left(\sum_{i1} CA_{L_{i1}}\right)\right)^{.839} \quad CA_{L_{900}} = \blacksquare\ Mdol$

= Total Cost for addition of all strutures

$\quad CAtot := \sum_{i1} CA_{L_{i1}} + CA_{L_{800}} + CA_{L_{900}}$

$$CAtot = \blacksquare\ Mdol$$

$$CTOT := CAtot \qquad\qquad CTOT = \blacksquare \ Mdol$$

+ Profit:

$$F_P := .10 \qquad C_{LP} := F_P \cdot CTOT \qquad C_{LP} = \blacksquare \ Mdol$$

= <u>Lead Ship Price</u>:

$$P_L := CTOT + C_{LP} \qquad\qquad \boxed{P_L = \blacksquare \ Mdol}$$

= <u>*Total Shipbuilder Portion:*</u>

$$C_{SB} := P_L \qquad\qquad C_{SB} = \blacksquare \ Mdol$$

b. Lead Ship Cost - Government Portion

This is where the cost of SOF equipment would go. Zeroed for this evaluation.
SOF will provide for their own equipment.

+ Ordnance and Electrical GFE:
   (Military Payload GFE)

$$C_{LMPG} := 0 \cdot Mdol$$

$$C_{LMPG} = \blacksquare \ Mdol \qquad\qquad \text{(or incl actual cost if known)}$$

+ Outfittimg Cost :

$$C_{LOUT} := .02 \cdot P_L \qquad C_{LOUT} = \blacksquare \ Mdol$$

= <u>*Total Government Portion:*</u>

$$C_{LGOV} := C_{LMPG} + C_{LOUT} \qquad\qquad C_{LGOV} = \blacksquare \ Mdol$$

c. Total Lead Ship End Cost: *(Must always be less than appropriation)*

* <u>*Total End Cost:*</u>
$$C_{LEND} := C_{SB} \qquad\qquad C_{LEND} = \blacksquare \ Mdol$$

d. Total Lead Ship Acquisition Cost:

+ Post-Delivery Cost (PSA):
$$C_{LPDEL} := .05 \cdot P_L \qquad C_{LPDEL} = \blacksquare \ Mdol$$

= <u>Total Lead Ship Acquisition Cost:</u> $\qquad C_{LA} := 0.5(C_{LEND} + C_{LPDEL}) + C_{LGOV}$

$C_{LA} = \blacksquare\, Mdol$

e.Introduction of the correction factor

This factor introduces a correction to the price of a follow on LMSR new construction ship, which is $250 million according to Avondale Industrie's seventh ship contract.
The cost that our math model calculates is $434.292million. (based on a weight break down for <u>Navy Combatants</u>)

= <u>Correction Factor:</u> ε

$$\varepsilon := \frac{250}{434.292}$$

$\varepsilon = \blacksquare$

<u>Total Lead Ship Acquisition Cost (corrected):</u>

$$C_{LAc} := C_{LA} \cdot \varepsilon$$

$C_{LAc} = \blacksquare\, Mdol$

COST MODEL--Conversion of LMSR to SOF

MIT 13A

Definitions (units): $\text{Mdol} := \text{coul}$ $\text{Bdol} := 1000 \cdot \text{Mdol}$ $\text{Kdol} := \dfrac{\text{Mdol}}{1000}$ $\text{dol} := \dfrac{\text{Kdol}}{1000}$

$\text{lton} := 2240 \cdot \text{lb}$

$\text{CNA} := 2.2$ $\text{CND} := 0.5$

1. Single Digit Weight Summary: $i1 := 100, 200 .. 700$

Removed Weight

$\text{WD}_{100} := 607.37 \cdot \text{lton}$ $\text{WD}_{400} := 0 \cdot \text{lton}$ $\text{WD}_{700} := 0 \cdot \text{lton}$

$\text{WD}_{200} := 15.74 \cdot \text{lton}$ $\text{WD}_{500} := 695.63 \cdot \text{lton}$

$\text{WD}_{300} := 34.19 \cdot \text{lton}$ $\text{WD}_{600} := 99.09 \cdot \text{lton}$

Added Weight

$\text{WA}_{100} := 5703.21 \cdot \text{lton}$ $\text{WA}_{400} := 76.19 \cdot \text{lton}$ $\text{WA}_{700} := 38.06 \cdot \text{lton}$

$\text{WA}_{200} := 15.74 \cdot \text{lton}$ $\text{WA}_{500} := 859.08 \cdot \text{lton}$

$\text{WA}_{300} := 69.9 \cdot \text{lton}$ $\text{WA}_{600} := 658.29 \cdot \text{lton}$

2. Additional Characteristics:

Total Weight Removed:

$$\text{WDel} := \left(\sum_{i1} \text{WD}_{i1} \right) \qquad \text{WDel} = \blacksquare \ \text{lton}$$

Total Weight Added:

$$\text{WAdd} := \left(\sum_{i1} \text{WA}_{i1} \right) \qquad \text{WAdd} = \blacksquare \ \text{lton}$$

Manning: (crew + air detachment + staff)   Officers: $N_O := 8$ Enlisted: $N_E := 22$

Officers: CPO's: $N_{C_2} := 0$ Enlisted: $N_{C_3} := N_E - N_{C_2}$

Ship Service Life: $L_S := 30$ Initial Operational Capability: $Y_{IOC} := 2004$

Total Ship Acquisition: $N_S := 1$ Production Rate (per year): $R_P := 1$

3. Inflation:

Base Year: $Y_B := 2003$ $iy := 1 .. Y_B - 1998$

Average Inflation Rate (%): $R_I := 3.$ $F_I := \prod_{iy} \left(1 + \dfrac{R_I}{100} \right)$ $F_I = \blacksquare$
(from 1981)

4. Lead Ship Cost:

a. Lead Ship Removal Cost - Shipbuilder Portion:

SWBS costs: includes escalation estimate

Structure

$$K_{N1} := \frac{.55 \cdot \text{Mdol}}{\text{lton}^{.772}} \qquad CD_{L_{100}} := .03395 \cdot F_I \cdot K_{N1} \cdot 0.5 \cdot \left(WD_{100}\right)^{.772} \qquad CD_{L_{100}} = \blacksquare \text{ Mdol}$$

+ Propulsion

$$K_{N2} := \frac{1.2 \cdot \text{Mdol}}{\text{lton}^{.808}} \qquad CD_{L_{200}} := .00186 \cdot F_I \cdot K_{N2} \cdot 0.5 \cdot \left(WD_{200}\right)^{.808} \qquad CD_{L_{200}} = \blacksquare \text{ Mdol}$$

+ Electric

$$K_{N3} := \frac{1.0 \cdot \text{Mdol}}{\text{lton}^{.91}} \qquad CD_{L_{300}} := .07505 \cdot F_I \cdot K_{N3} \cdot 0.5 \cdot \left(WD_{300}\right)^{.91} \qquad CD_{L_{300}} = \blacksquare \text{ Mdol}$$

+ Command, Control, Surveillance

$$K_{N4} := \frac{2.0 \cdot \text{Mdol}}{\text{lton}^{.617}} \qquad CD_{L_{400}} := .10857 \cdot F_I \cdot K_{N4} \cdot 0.5 \cdot \left(WD_{400}\right)^{.617} \qquad CD_{L_{400}} = \blacksquare \text{ Mdol}$$

(less payload GFM cost)

+ Auxiliary

$$K_{N5} := \frac{1.5 \cdot \text{Mdol}}{\text{lton}^{.782}} \qquad CD_{L_{500}} := .09487 \cdot F_I \cdot K_{N5} \cdot 0.5 \cdot \left(WD_{500}\right)^{.782} \qquad CD_{L_{500}} = \blacksquare \text{ Mdol}$$

+ Outfit

$$K_{N6} := \frac{1.0 \cdot \text{Mdol}}{\text{lton}^{.784}} \qquad CD_{L_{600}} := .09859 \cdot F_I \cdot K_{N6} \cdot 0.5 \cdot \left(WD_{600}\right)^{.784} \qquad CD_{L_{600}} = \blacksquare \text{ Mdol}$$

+ Armament

$$K_{N7} := \frac{1.0 \cdot \text{Mdol}}{\text{lton}^{.987}} \qquad CD_{L_{700}} := .00838 \cdot F_I \cdot K_{N7} \cdot 0.5 \cdot \left(WD_{700}\right)^{.987} \qquad CD_{L_{700}} = \blacksquare \text{ Mdol}$$

(Less payload GFM cost)

+ Integration/Engineering: (Lead ship includes detail design engineering + plans for class)

$$K_{N8} := \frac{10. \cdot \text{Mdol}}{\text{Mdol}^{1.099}} \qquad CD_{L_{800}} := .034 \cdot K_{N8} \cdot 0.5 \cdot \left(\left(\sum_{i1} CD_{L_{i1}}\right)\right)^{1.099} \qquad CD_{L_{800}} = \blacksquare \text{ Mdol}$$

+ Ship Assembly + Support: (Lead ship includes all tooling, jigs, special facilities for class)

$$K_{N9} := \frac{2.0 \cdot \text{Mdol}}{(\text{Mdol})^{.839}} \qquad CD_{L_{900}} := .135 \cdot K_{N9} \cdot 0.5 \cdot \left(\left(\sum_{i1} CD_{L_{i1}}\right)\right)^{.839} \qquad CD_{L_{900}} = \blacksquare \text{ Mdol}$$

= Total Cost for removal of all strutures

$$CDtot := \sum_{i1} \left(CD_L\right)_{i1} + CD_{L_{800}} + CD_{L_{900}}$$

$$CDtot = \blacksquare \text{ Mdol}$$

b. Lead Ship Addition Cost - Shipbuilder Portion:

SWBS costs: includes escalation estimate

Structure $\quad K_{N1} := \dfrac{.55 \cdot \text{Mdol}}{\text{lton}^{.772}}$ $\quad CA_{L_{100}} := .03395 \cdot F_I \cdot K_{N1} \cdot 2.2 \cdot \left(WA_{100}\right)^{.772}$ $\quad CA_{L_{100}} = \blacksquare \, \text{Mdol}$

+ Propulsion $\quad K_{N2} := \dfrac{1.2 \cdot \text{Mdol}}{\text{lton}^{.808}}$ $\quad CA_{L_{200}} := .00186 \cdot F_I \cdot K_{N2} \cdot 2.2 \cdot \left(WA_{200}\right)^{.808}$ $\quad CA_{L_{200}} = \blacksquare \, \text{Mdol}$

+ Electric $\quad K_{N3} := \dfrac{1.0 \cdot \text{Mdol}}{\text{lton}^{.91}}$ $\quad CA_{L_{300}} := .07505 \cdot F_I \cdot K_{N3} \cdot 2.2 \cdot \left(WA_{300}\right)^{.91}$ $\quad CA_{L_{300}} = \blacksquare \, \text{Mdol}$

+ Command, Control, Surveillance

$\quad K_{N4} := \dfrac{2.0 \cdot \text{Mdol}}{\text{lton}^{.617}}$ $\quad CA_{L_{400}} := .10857 \cdot F_I \cdot K_{N4} \cdot 2.2 \cdot \left(WA_{400}\right)^{.617}$ $\quad CA_{L_{400}} = \blacksquare \, \text{Mdol}$

(less payload GFM cost)

+ Auxiliary $\quad K_{N5} := \dfrac{1.5 \cdot \text{Mdol}}{\text{lton}^{.782}}$ $\quad CA_{L_{500}} := .09487 \cdot F_I \cdot K_{N5} \cdot 2.2 \cdot \left(WA_{500}\right)^{.782}$ $\quad CA_{L_{500}} = \blacksquare \, \text{Mdol}$

+ Outfit $\quad K_{N6} := \dfrac{1.0 \cdot \text{Mdol}}{\text{lton}^{.784}}$ $\quad CA_{L_{600}} := .09859 \cdot F_I \cdot K_{N6} \cdot 2.2 \cdot \left(WA_{600}\right)^{.784}$ $\quad CA_{L_{600}} = \blacksquare \, \text{Mdol}$

+ Armament $\quad K_{N7} := \dfrac{1.0 \cdot \text{Mdol}}{\text{lton}^{.987}}$ $\quad CA_{L_{700}} := .00838 \cdot F_I \cdot K_{N7} \cdot 2.2 \cdot \left(WA_{700}\right)^{.987}$ $\quad CA_{L_{700}} = \blacksquare \, \text{Mdol}$

(Less payload GFM cost)

+ Integration/Engineering: (Lead ship includes detail design engineering + plans for class)

$\quad K_{N8} := \dfrac{10. \cdot \text{Mdol}}{\text{Mdol}^{1.099}}$ $\quad CA_{L_{800}} := .034 \cdot K_{N8} \cdot 0.5 \cdot \left(\left(\sum_{i1} CA_{L_{i1}}\right)\right)^{1.099}$ $\quad CA_{L_{800}} = \blacksquare \, \text{Mdol}$

+ Ship Assembly + Support: (Lead ship includes all tooling, jigs, special facilities for class)

$\quad K_{N9} := \dfrac{2.0 \cdot \text{Mdol}}{(\text{Mdol})^{.839}}$ $\quad CA_{L_{900}} := .135 \cdot K_{N9} \cdot 0.5 \cdot \left(\left(\sum_{i1} CA_{L_{i1}}\right)\right)^{.839}$ $\quad CA_{L_{900}} = \blacksquare \, \text{Mdol}$

= Total Cost for addition of all strutures

$$CAtot := \sum_{i1} CA_{L_{i1}} + CA_{L_{800}} + CA_{L_{900}}$$

$$CAtot = \blacksquare \, \text{Mdol}$$

$$CTOT := CDtot + CAtot \qquad CTOT = {\blacksquare} \; Mdol$$

+ Profit:

$$F_P := .10 \qquad C_{LP} := F_P \cdot CTOT \qquad C_{LP} = {\blacksquare} \; Mdol$$

= <u>Lead Ship Price</u>:

$$P_L := CTOT + C_{LP} \qquad \qquad \boxed{P_L = {\blacksquare} \; Mdol}$$

= <u>*Total Shipbuilder Portion:*</u>

$$C_{SB} := P_L \qquad \qquad C_{SB} = {\blacksquare} \; Mdol$$

b. Lead Ship Cost - Government Portion

> This is where the cost of SOF equipment would go. Zeroed for this evaluation.
> **SOF will provide for their own equipment.**

+ Ordnance and Electrical GFE:
  (Military Payload GFE)

$$C_{LMPG} := 0 \cdot Mdol$$

$$C_{LMPG} = {\blacksquare} \; Mdol \qquad \text{(or incl actual cost if known)}$$

+ Outfittimg Cost :

$$C_{LOUT} := .02 \cdot P_L \qquad C_{LOUT} = {\blacksquare} \; Mdol$$

= <u>*Total Government Portion:*</u>

$$C_{LGOV} := C_{LMPG} + C_{LOUT} \qquad \qquad C_{LGOV} = {\blacksquare} \; Mdol$$

c. Total Lead Ship End Cost: *(Must always be less than appropriation)*

* <u>*Total End Cost:*</u>

$$C_{LEND} := C_{SB} \qquad \qquad C_{LEND} = {\blacksquare} \; Mdol$$

d. Total Lead Ship Acquisition Cost:

+ Post-Delivery Cost (PSA):

$$C_{LPDEL} := .05 \cdot P_L \qquad C_{LPDEL} = {\blacksquare} \; Mdol$$

= <u>Total Lead Ship Acquisition Cost:</u> $\qquad C_{LA} := 0.5(C_{LEND} + C_{LPDEL}) + C_{LGOV}$

$$C_{LA} = \blacksquare \ Mdol$$

e.Introduction of the correction factor

This factor introduces a correction to the price of a follow on LMSR new construction ship, which is $250 million according to Avondale Industrie's seventh ship contract.
The cost that our math model calculates is $434.292million. (based on a weight break down for <u>Navy Combatants</u>)

= <u>Correction Factor:</u> ε

$$\varepsilon := \frac{250}{434.292}$$

$$\varepsilon = \blacksquare$$

Total Lead Ship Acquisition Cost (corrected):

$$C_{LAc} := C_{LA} \cdot \varepsilon$$

$$C_{LAc} = \blacksquare \ Mdol$$